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# TWELFTH ANNUAL REPORT

Alberta

OIL SANDS TECHNOLOGY
AND RESEARCH AUTHORITY

89-00409/

Alberta

OIL SANDS TECHNOLOGY
AND RESEARCH AUTHORITY

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TO HER HONOUR
HELEN HUNLE
LIEUTENANT GOVERNOR OF THE PROVINCE OF ALBERTA

Madam:

I have the honour to submit the Annual Report of the ALBERTA OIL SANDS TECHNOLOGY AND RESEARCH AUTHORITY for the fiscal year ended March 31, 1987.

Respectfully submitted

Neil Webber.

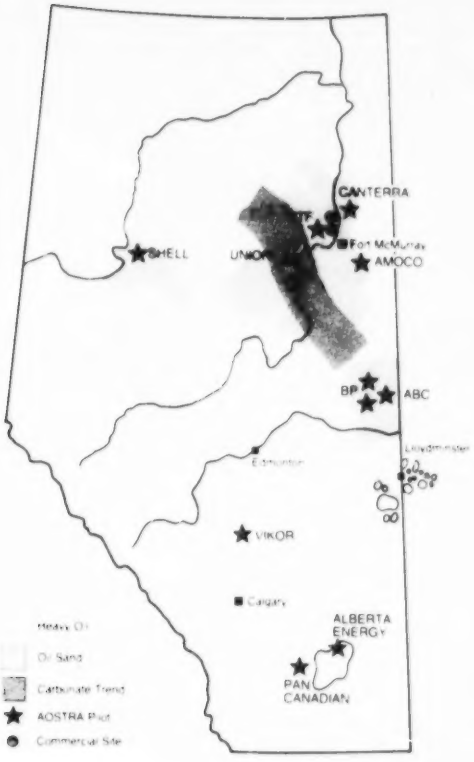
NEIL WEBBER
Minister of Energy

# Foreword

On January 14, 1974, the Premier of Alberta announced the availability of $100 million to develop new technology for the recovery and processing of petroleum from the Alberta oil sands. The terms and conditions for the disbursement of these funds are described in The Oil Sands Technology and Research Authority Act, passed by the Legislature in June 1974 and since amended to include the recovery of heavy oils and the enhanced recovery from conventional petroleum reservoirs. Additional funds have since been dedicated by the Alberta Government to permit the funding of longer term programs.

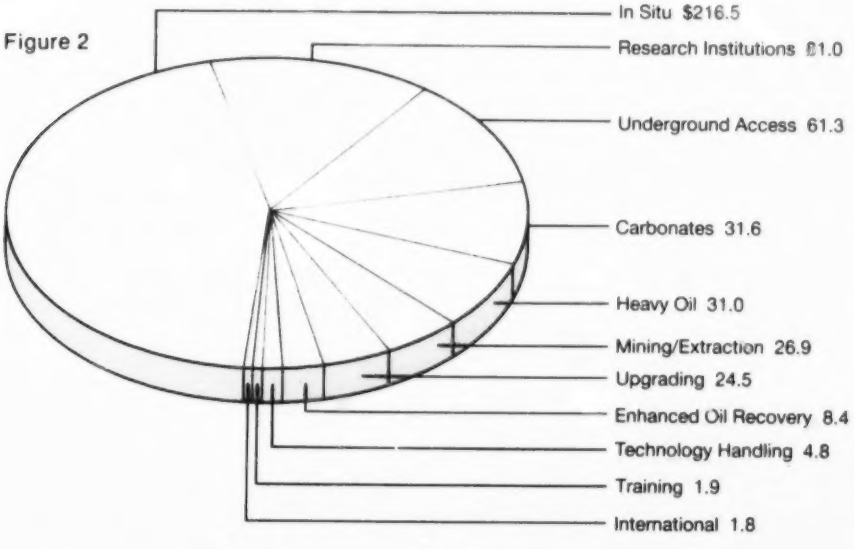
**AOSTRA Field Pilot Projects**

Figure 1




**Commitments from AOSTRA Research Fund To March 31, 1987 ($ Millions)**

Figure 2



# Report of the Chairman and Chief Executive Officer of the Alberta Oil Sands Technology and Research Authority

***To The Honourable Neil Webber***
***Minister of Energy***

Sir:

I have the honour to present the Twelfth Annual Report of the Alberta Oil Sands Technology and Research Authority (AOSTRA) for the year ended March 31, 1987.

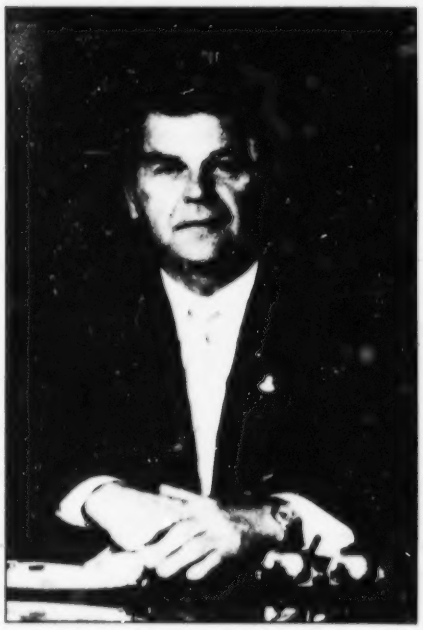
The Authority experienced several changes to its executive during the fiscal year. The Chairman, Mr. R.D. Humphreys, resigned on July 23, 1986 and the Vice-Chairman, Mr. Maurice A. Carrigy, became Acting Chairman during the remainder of the fiscal year. A search was initiated during the latter half of the fiscal year which resulted in the appointment of the new Chairman effective April 15, 1987. At the termination of the fiscal year, both the Vice-Chairman and the Director of In Situ Operations, Mr. Ray Phillips, applied for early retirement. At the request of the new Chairman, the Vice-Chairman postponed his retirement to November 30, 1987. Both of these talented, competent employees will be much missed by AOSTRA. The Members of the Authority and all AOSTRA employees wish th

During the fiscal year 1986/87 the oil industry nationally and internationally passed through a turbulent period with sudden changes in pricing and marketing strategy. In contrast, in Alberta, new records of production were established for heavy crude, bitumen, and synthetic crude as a result of a decade of research and technological progress. The results of the Alberta Government's foresight and actions in research and development are positive and will increasingly provide assurance of hydrocarbon supply to the North American market. This annual report is being presented at a time when the world price of oil has exceeded $20 U.S. per barrel with expectations for further gradual increases. Substantive increases in U.S. imports of oil by 1995 are projected. Increases in both prices and demand will result in an accelerated pace of research, piloting, and commercialization of Alberta's heavy oil and oil sands resources.

During the fiscal year ending on March 31, 1987, AOSTRA committed $63.6 million for new research and development projects and expended $75.2 million on current and past commitments. In excess of 60% of the expended dollars were allocated for research and piloting of the in situ processes for oil sands recovery.

The 1986/87 fiscal year initiated a major change in capital projects funding in AOSTRA. The assignment of original capital from the Heritage Savings Trust Fund was nearing exhaustion and needed capital funding was appropriated from the General Revenue Fund. Thus AOSTRA began to feel the effects of the Alberta Government's budget limitations. Total capital approval for the 1987/88 fiscal year has been limited to $47.7 million. The necessary budget limitations will not dampen AOSTRA's enthusiasm nor its capability to accomplish its extensive mandate.

In progressing stepwise towards increased commercialization of Alberta's oil sands and heavy oil resources, significant progress has been made in basic research including modeling and simulation, in piloting in situ processes, in the accumulation and marketing of technology, and in evolving and installing demonstration and commercial facilities. Currently there are seven active heavy oil/oil sands pilot projects, three light oil projects, three recently commercialized pilots from which technology is still being received, and two pilot plants that have been terminated but require wrap-up work. The AOSTRA/Industry piloting programs in the Cold Lake, Athabasca, and Peace River oil sands deposits have progressed successfully. The AOSTRA/Shell Peace River pilot project has permitted Shell Canada Limited to construct a commercial demonstration project with a capacity of 1600 $m^3$ per day from 216 wells. Encouraging piloting results at the AOSTRA-Cold Lake Oil Sands Ltd.-Bow Valley Industries Ltd. pilot project have resulted in a second inverted seven-spot pattern with operations commencing in late 1986. At Athabasca the AOSTRA Underground Test Facility (UTF) has progressed through the testing phase and is being officially opened on June 29, 1987. Enhanced recovery of conventional oil from the depleted and abandoned segment of the Joffre Viking sandstone reservoir in central Alberta has been encouraging. New techniques have resulted in increased recovery efficiency at the piloting program at Suffield. Of special significance is an environmental study program funded jointly by AOSTRA, Environment Canada and industry in the Lindbergh area to effectively treat contaminated water from in situ heavy oil recovery processes.



In the past year significant steps were taken to advance the development of heavy oil upgrading processes. AOSTRA, Gulf Canada, and the Association Pour la Valorisation des Huiles Lourdes (ASVAHL) carried out a large-scale test at an experimental refinery in France. In addition, both the Veba Oel's Combi-Cracking process and the Hydrocarbon Research Inc.'s High Conversion H-Oil Process were successfully demonstrated in steady-state operations on Cold Lake

bitumen feedstock. AOSTRA, Shell Canada Limited, and Solv-Ex Corporation participated in a joint project to pilot test the performance of the Solv-Ex process for extraction of bitumen from Athabasca oil sands in the first phase of a two-phase program.

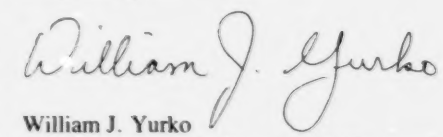
AOSTRA's performance in cooperation with the Alberta Research Council, Alberta Universities, and the oil and gas industry during the last twelve years has resulted in Alberta being recognized as a world leader in development of oil sands and heavy oil technology. This recognition has led to technology exchange letters of understanding with several countries. AOSTRA has been a frequent catalyst and leader in initiating international trade inter-relationships. Agreement by AOSTRA to participate jointly with RIPED (China's Research Institute for Petroleum Exploration and Development) in a major conference in China, in October 1987, will advance technological awareness and transfer and possibly initiate trade inter-relationships. AOSTRA has also signed an agreement to co-sponsor with the UNITAR/UNDP Information Centre for Heavy Crude and Tar Sands (a branch of the United Nations) the Fourth International Conference on Heavy Crude and Tar Sands in Edmonton, August 7 to 12, 1988.

During 1986 AOSTRA developed a new computerized data base system for processing and storage of data collected by in situ projects.

In regards to technology sales, activity focused on licensing of the Taciuk Process for the treatment of hydrocarbon-bearing waste materials and for the extraction of oil from oil shales in Australia. The membership fee structure for the AOSTRA/Industry University Access Program was revised and distributed for possible membership to 55 recipients. Plans are being formulated for holding a technology package sale during 1987. New technology pricing catalogues are in preparation for distribution. A new steering committee was established to provide policy and direction for obtaining more patent protection and negotiation and maintenance of licenses.

Mr. Minister, permit me to end by stating that the future work of AOSTRA shall continue to contribute to the development of a highly technical and versatile oil sands and heavy oil industry which will be capable of meeting both domestic and export opportunities. Increased priorities will be directed toward research and development for enhanced oil recovery from Alberta's conventional oil reservoirs.

Respectfully submitted



William J. Yurko
*Chairman and Chief Executive Officer*

# Members of the Authority

***Chairman***
Mr. R.D. Humphreys
(to July 23, 1986)
Mr. William J. Yurko**

***Vice-Chairman***
Mr. M.A. Carrigy*

***Members***
Dr. H.E. Gunning
Mr. J.A. Harvie
Mr. F.A. Kidd
Mr. J.E. Miller
Dr. E.J. Wiggins
Mr. S. P. Zarusky

***Head Office***
5th Floor Highfield Place
10010 - 106 Street
Edmonton, Alberta
T5J 3L8

***Calgary Office***
18th Floor McFarlane Tower
700 - 4th Avenue S.W.
Calgary, Alberta
T2P 3J4

* Acting Chairman since July 23, 1986
** Chairman and Chief Executive Officer as of April 15, 1987.

# Staff

**As of March 31, 1987**

### *Executive*

R.D. Humphreys, to July 23, 1986
M.A. Carrigy, F.Geol., Chief Administrative Officer*
B.J. Stonier, Executive Assistant to Chairman

### *Technical*

**Edmonton**
R.T. Bailey, P.Eng., Manager, Upgrading Projects
W.A. Burdenie, P.Eng., Senior Project Engineer, Extraction Processes
K.J. Cochrane, P.Eng., Project Engineer
T.J. Cyr, Ph.D., Manager, University Research
R.R. Germain, P.Eng., Project Engineer Upgrading
C. Hsi, Ph.D., P.Eng., Manager, Institutional Programs
D.P. Komery, P. Eng., Manager, Mining and Extraction Processes
R.P. Padamsey, P.Eng., Process Engineer
D.A. Redford, Ph.D., P. Eng., Director, Program Planning & Evaluation
A.C. Thakrar, Project Supervisor
L.R. Turner, P.Eng., Director, Mining, Extraction & Upgrading
F.J. Werth, Senior Economic Analyst

**Calgary**
B.R. Beazley, Systems Analyst
D.A. Best, Ph.D., P.Eng., Manager, In Situ Engineering
M.S. Carleton, CDP, Data Base Administrator
H.S. Chhina, P.Eng., Senior Reservoir Engineer
R.T. Curry, Senior Systems Analyst
S. Gozde, Reservoir Engineer
K.E. Kisman, Ph.D., P.Eng., Principal Reservoir Engineer
G.S. Kular, Reservoir Engineer
R.W. Luhning, Ph.D., P.Eng., Manager, Thermal Projects
M.E. McCormack, P.Eng., Senior Facilities Engineer
B.C. McGee, P.Eng., Senior Reservoir Engineer
J.E. Palfreyman, Geologist
G.S. Paton, Systems Analyst
R.S. Phillips, P.Eng., Director, In Situ Operations
J.D. Scott, P.Eng., Manager, Enhanced Recovery Projects
C.G. Stanford, Systems Analyst
A. Wong, P.Eng., Facilities Engineer

### *Administration*

**Edmonton**
L.G. Benzer, Information Coordinator
D.L. Borhen, Accounting Clerk
K.P. Chizawsky, Accountant
A. Grant, Word Processing Operator
N.R. Kincade, Records Coordinator
W.G. Kowaluk, C.A., Manager, Finance & Administration
L.J. Miskiw, Administrative Accountant
S.A. Reimond, Secretary
E.K. Spady, LL.B., General Counsel
D.B. Teppan, Secretary
B.J. Thom, Secretary
G.A. Villett, Registrar & Personnel Officer

* Acting Chairman since July 23, 1986

**Calgary**
V.M. Foster, Clerk-Typist
S.E. Green, Coordinator Administration Systems
H.E. Haston, Administrative Assistant
B.E. Hill, Secretary
K.I. Simpson, Records Clerk
S.R. Van Elslande, Receptionist

# Members of Appraisal Panels and Committees

### *University Oil Sands Research Evaluation Panel*

W.C. Cook, P.Eng., Mobil Oil Canada Ltd.
T.J. Cyr, Ph.D., AOSTRA
S.M. Farouq Ali, Ph.D., P.Eng., University of Alberta
I. Hutcheon, Ph.D., P.Geol., University of Calgary
J.K. Liu, Ph.D., P. Eng., Syncrude Canada Ltd. (Chairman)
K. Putt, P.Eng., Esso Resources Canada Limited
J.D. Scott, Ph.D., P.Eng., University of Alberta
G.A. Villett, AOSTRA

### *Scholarship and Fellowship Selection Committee*

H.E. Gunning, Ph.D., AOSTRA
J.B. Hyne, Ph.D., University of Calgary
F.D. Otto, Ph.D., P.Eng., University of Alberta
W. Shaw, Ph.D., P.Eng., University of Calgary
J.R. Thompson, Ph.D., University of Alberta
J. Weiser, Ph.D., University of Calgary
E.J. Wiggins, Ph.D., P.Eng., AOSTRA

### *Patent Committee*

M.A. Carrigy, P.Geol.
T.J. Cyr, Ph.D. (Chairman)
R.W. Luhning, Ph.D., P.Eng.
D.A. Redford, Ph.D., P.Eng.
E.K. Spady, LL.B.
L.R. Turner, P.Eng.

# Consultants

### *Project Technical Representatives*

W.L. Christie, P. Eng.
H.T. Gennings, P.Eng.
W.K. Good, P.Eng.
F.W. Kelly, P. Eng.
J.J. Nikolaychuk, P.Eng.
N.E. Pullin, P.Eng.
G. Van der Voet, P.Eng.
D.D. Wright, P.Eng.

### *Technical Advisors to Staff*

D.W. Bennion, Ph.D., P.Eng., In Situ Projects
R.G. Bentson, Ph.D., P.Eng., In Situ Projects
R.M. Butler, Ph.D., P.Eng., Underground Test Facility
J. Chrones, P.Eng., Upgrader Residue Utilization Project
N.R. Edmunds, P.Eng., Process Development Coordinator, UTF
M.R. Farries, P.Eng., Oil Sands Demonstration Center
J.A. Haston, P.Eng., Underground Test Facility, Project Manager
D.R. Hickey, P.Eng., Upgrader Demonstration Project
D. Poon, Thermal and EOR Projects
H.J. Ruitenbeek, Economic Evaluations
J.C. Suggett, Assistant Project Engineer, UTF
N.C. Wardlaw, Ph.D., P.Eng., Geological Consultant
A.G. Winestock, P.Eng., Manager, UTF

### *Legal*

P.A. Wagers, Legal Counsel
E.P. Johnson (Patents & Technology Agreements)
Field & Field (Project Agreements)

### *Project Auditors*

Touche Ross & Co.

# Information

*For further information contact one of the following persons:*

### *General Information*

Mrs. L.G. Benzer
500 Highfield Place
10010 - 106 Street
Edmonton, Alberta, T5J 3L8
Telephone (403) 427-7623
Telex: 037-3519

### *Applications for Funding*

Mr. G.A. Villett
500 Highfield Place
10010 - 106 Street
Edmonton, Alberta, T5J 3L8
Telephone (403) 427-7623
Telex: 037-3519

### *Technology Sales*

Mr. P.A. Ross
500 Highfield Place
10010 - 106 Street
Edmonton, Alberta, T5J 3L8
Telephone (403) 427-7623
Telex: 037-3519

### *Published Information and the TAR Paper*

Mrs. H. Radvanyi-Starr
6th Floor, Highfield Place
10010 - 106th Street
Edmonton, Alberta, T5J 3L8
Telephone (403) 427-8382
Telex: 037-3519

### *AOSTRA Journal of Research*

**Editorial Information**
Dr. L.G. Hepler
Department of Chemistry
The University of Alberta
Edmonton, Alberta, T6G 2G2
Telephone (403) 432-2762

Dr. R.G. Bentsen
Department of Mining, Metallurgical and Petroleum Engineering
University of Alberta
Edmonton, Alberta
T6G 2G6
Telephone: (403) 432-3958

**Subscription Information**
AOSTRA Library & Information Services
600 Highfield Place
10010 - 106th Street
Edmonton, Alberta, T5J 3L8
Telephone (403) 427-8382

# Report of Activities

## 1 In Situ Oil Sands Recovery Program

### *1.1 AOSTRA-AMOCO Gregoire Lake Pilot Project*

AOSTRA, Amoco Canada Petroleum Company Limited, and Petro-Canada Exploration Inc. signed an agreement in 1984 to conduct a new pilot approximately 15 km NE of the Block 1 pilot using steam and steam plus additive processes. The four-spot pattern of injection, production, and observation wells was completed in 1986 with operations commencing in late 1986. A unique 3-D seismic pattern installation was used to track the initial heat front movement in the reservoir. Operations will continue throughout 1987.

### *1.2 AOSTRA-BP Marguerite Lake Pilot Project*

BP Exploration Canada Limited, with AOSTRA, Dome Petroleum Limited and PanCanadian Petroleum Limited, operate the Marguerite Lake project located in the Clearwater sandstone of the Cold Lake oil sands deposit. The pilot is designed to test steam stimulation followed by jet combustion.

The project is now in its ninth year of operation. The initial steam stimulation phase and concurrent combustion testing with air in special test wells is complete. Feasibility studies led to a decision to use oxygen instead of air for the combustion phase. A total of five wells in the main pattern have been converted to oxygen injection. Oxygen injection and related production operations continued throughout 1986 with encouraging results.

BP is investigating the use of the oxygen combustion technology in the Wolf Lake 1100 m³/day operation which surrounds the pilot area. The Wolf Lake project, which started production in April 1985, is based on steam recovery technology developed at the Marguerite Lake pilot.

### *1.3 AOSTRA-BP B-Unit Pilot Project*

AOSTRA, BP Exploration Canada Limited, and Petro-Canada Inc. in 1986 completed the fourth cycle in a single-well cyclic steam stimulation project (B-Unit pilot) with two observation wells in the Lower Grand Rapids formation of the Cold Lake oil sands deposit. The object of the B-Unit pilot, which is now complete, was to improve bitumen recovery by testing novel fracturing/injection methods which were developed at the AOSTRA-BP Marguerite Lake pilot, 10 km to the north. The producing zone is 16 m thick at a depth of 430 m.

Based on the encouraging results of the B-Unit pilot, BP and Petro-Canada have drilled 22 wells for production from the Lower Grand Rapids formation at a location adjacent to the Wolf Lake operation which surrounds the Marguerite Lake pilot. Steam stimulation operations will begin late in 1987.

### *1.4 AOSTRA-CANTERRA TENNECO Kearl Lake Pilot Project*

The pilot is located 77 km NE of Fort McMurray, and is operated by Canterra Energy Limited with AOSTRA and Tenneco Energy Ltd. as participants. The pilot is testing a steam drive process in the McMurray oil sand which, in this area, is at a depth of 150 m and is about 43 m thick. The pilot consists of two patterns: The "A" pattern is an inverted seven-spot with seven steam injection wells and six producers. The "B" pattern is infill-drilled based on "A" pattern information forming an inverted nine-spot. Operations began in the "B" pattern in 1985.

Both "A" and "B" patterns operated throughout 1986 with encouraging results. The "B" pattern operations will be expanded in 1987 to provide two additional inverted five-spot patterns plus observation wells adjoining the existing nine-spot pattern. To improve recovery operations, steam additives will be tested during 1987.

### *1.5 AOSTRA-COLD LAKE-BOW VALLEY Pilot Project*

Bow Valley Resource Industries Ltd. with AOSTRA and Cold Lake Heavy Oil Ltd. was designed to test the use of superheated steam plus carbon dioxide and clay stabilization additives for recovery of bitumen from the Cold Lake Clearwater horizon.

The inverted seven-spot is located on a Gulf Canada Resources Inc. oil sands lease near the site of an earlier steam pilot operated and suspended by Gulf. The pilot results using a modified recovery process were encouraging and a second inverted seven-spot pattern on larger spacing plus two special test wells were drilled in 1986. The original inverted seven-spot pattern operated throughout that year and operations in both patterns plus the special test wells will continue throughout 1987.

### *1.6 AOSTRA-SHELL Peace River Pilot Project*

The AOSTRA-Shell Canada Resources Limited-Shell Explorer Limited-Amoco Canada Petroleum Company Ltd. Peace River Project, located 30 km NE of Peace River, was designed as a prototype installation to test a modified steam drive recovery process in the Peace River oil sands. The recovery technology developed, based on cyclic steam pressurization and modified drive in the 27 m thick oil sands at a depth of 550 m *via* a 3 m bottom interval of high water saturation, has been successful. Steam stimulation, the first and second pressurization/production cycles produced approximately 33% of the original oil-in-place. The third pressurization/production cycle began in 1986 and will continue through 1987.

Shell Canada has constructed a commercial demonstration project with a capacity of 1600 m³/day. AOSTRA is not a direct participant in the commercial pilot, but the existing pilot facilities and technology have been incorporated into the new project. AOSTRA's and Amoco's direct participation terminated at the end of

1985, but AOSTRA continues to receive data from the commercial pilot.

### *1.7 AOSTRA-SUNCOR-CANADIAN WORLDWIDE Fort Kent Steam Additive Study*

AOSTRA, Suncor Inc., and Canadian Worldwide Energy Limited completed a combined engineering feasibility study on the use of steam additives to improve oil recovery at the Suncor Fort Kent commercial demonstration operation in Cold Lake. The study evaluated the patented steam plus carbon dioxide and naphtha additive process developed by AOSTRA at the Alberta Research Council. The study indicated that additional recovery could be achieved with the steam additive system although higher than present prices would be required to make the process economically attractive.

### *1.8 AOSTRA-UNOCAL Buffalo Creek and McLean Pilot Projects*

Unocal Canada Limited with AOSTRA and Canadian Superior Oil Limited operate the projects which are located approximately 100 km west of Fort McMurray. Tests since 1977 have been conducted in the Grosmont 2 and 3 Devonian carbonate formation to examine the suitability of steam stimulation, steam drive, and wet combustion processes for bitumen recovery.

A five-spot pattern (McLean pilot) was completed in 1983. The initial results indicated a geological anomaly within the pilot area. In order to maintain the initial pilot concept, two additional wells were drilled in early 1984 and operations continued through 1985. Late in 1985, two new production wells for cyclic steam operations were drilled at locations off-setting McLean and operated throughout 1986. A special test program was conducted in 1986 to investigate the relation of geology to well operation at the McLean pattern. The 1986 field program gave mixed results and field operations were suspended early in 1987 for an indefinite period. A full analysis of all pilot data will be completed during 1987.

### *1.9 TEXACO-Fort McMurray Horizontal Well Project*

AOSTRA has acquired production and operating data on three horizontal wells operated by Texaco Canada Inc. in the Athabasca formation near Fort McMurray. Texaco suspended operation of these wells during 1986.

AOSTRA is currently pursuing horizontal well technology for recovery of bitumen at its underground test facility northwest of Fort McMurray.

### *1.10 AOSTRA-Industry Mineralogical Transformation Study*

AOSTRA was the operator in a cooperative industry-supported research program with eight other industrial participants to conduct a state-of-the-art review of the available confidential and public information on mineralogical transformations occurring during thermal recovery. RES-SEN Reservoir Technology Limited was the contractor conducting the review for the first phase of the study at a cost of $55,000. The study was completed in 1986 and further research is being considered.

### *1.11 Data Base Management System*

During 1986 AOSTRA developed a new computerized data base system (called "ADBS II") for processing and storage of data collected by in situ projects. ADBS II is built using an advanced relational data base management system and provides ease of data entry, editing, report generation, and powerful data retrieval capabilities. The system is suitable for installation on microcomputers to provide both user flexibility and an economical solution to handling pilot data.

AOSTRA is presently converting several project data bases from the earlier generation system (called "ADBS") to ADBS II. ADBS is installed at the Canada Systems Group Service Bureau in Calgary and AOSTRA supported data base operations on both ADBS and ADBS II during 1986. Ongoing system enhancements will occur in 1987 including adaptation of ADBS II to the Underground Test Facility (UTF project).

In addition to data base processing, AOSTRA increased its in-house computing capacity to support engineering studies. Reservoir simulation studies required by several AOSTRA projects are carried out using a network of engineering work stations installed at AOSTRA's Calgary office.

With ADBS and ADBS II, AOSTRA has established nine active project data bases containing 50 project years of data.

### *1.12 Economic Studies*

During the year, H.J. Ruitenbeek Resource Consultants Limited continued to supply economic analyses on selected pilot projects as required. Major reviews of two in situ projects were completed on behalf of AOSTRA during the year.

An economic model for evaluating and monitoring the commercial potential of new and existing in situ production projects was developed and is now available for use on a microcomputer. The cost base will be updated as appropriate.

## 2 Underground Test Facility (UTF)

For almost ten years, AOSTRA has supported studies evaluating the shaft and tunnel access (SATAC) method of placing an array of horizontal wells low in the formation to promote high recovery of bitumen from oil sands. In 1982, AOSTRA initiated a new study at a site, on Crown land, 17 km west of the Syncrude mining operations. Norwest Resource Consultants Limited of Calgary was commissioned to provide a design and cost estimate of an Underground Test Facility (UTF), which would provide access for underground thermal in situ recovery piloting. As a result of this study and previous work, AOSTRA dedicated $43 million to construct the first stage of the facility.

This field project was started in 1984. After a review of the suitability of the Crown land site, further study and

preliminary discussions with potential industry participants, AOSTRA contracted for the sinking of two shafts and the drilling of the initial tunnels. Field work began in November 1984. The initial facilities were in place by the end of May 1986.

During 1985, process screening and project evaluation studies were carried out in close cooperation with a 16-company industry steering committee, and these studies led to definition of the preferred drilling and process testing program. By May 1986, the project had effectively moved from the initial access work into implementation of the subsequent test work.

The principal activities in the past year have been the design and construction of the process facilities and the testing of the custom underground drilling system. AOSTRA's site operations crew has been built up over the year, principally through contractor services, in preparation for the pilot operations stage of the work.

A custom drill rig was field tested at Exshaw before being re-assembled down the mine for the drilling of the process test wells. The drilling tests, both at Exshaw and underground, have taken more time than originally foreseen and have resulted in a delay of over six months in the start-up of the process tests. The concept of the system appears sound, but its implementation has not been without difficulties.

The Federal Department of Energy, Mines and Resources is expected to join the project in April 1987 as a technical participant in the Phase A process program and as co-sponsor of an enhanced geotechnical study program.

Overall, the project is within budget and has progressed well except for the delays in drilling. It is now expected that steam injection will start in November 1987.

# 3 Enhanced Recovery Program

## *3.1 AOSTRA-ALBERTA ENERGY Suffield Heavy Oil Pilot Project*

This project, operated by Alberta Energy Company Limited (AEC) on behalf of AOSTRA, Dome Petroleum Limited, and Westcoast Petroleum Limited, is located in the glauconite sandstone under the Suffield military block in southern Alberta. The pilot is designed to test wet combustion recovery from an inverted five-spot pattern at a location where the 19.5 m thick heavy oil reservoir is underlain by water. A single well gas injection test was conducted during 1986 and combustion recovery operations continued, with the addition of an off-set production well.

Although pilot production was significantly greater than would be expected by primary recovery alone, the combustion operations were suspended at the end of 1986 in order to concentrate on a modified recovery process. During 1987, AOSTRA, AEC, and Westcoast Petroleum will conduct field testing of a modified non-thermal gas drive process in an inverted seven-spot pattern plus four special single well tests at locations off-setting the original combustion pattern.

## *3.2 AOSTRA-CANTERRA Asphaltene Solids Precipitation Study*

Canterra Energy Limited is the operator in a jointly supported research program with AOSTRA to conduct a laboratory study of the precipitation of asphaltenes in selected light oils when contacted by hydrocarbon solvents. A goal of the study is to formulate a mathematical model using an equation of state and data obtained from asphaltene solubility tests to predict the deposition of asphaltenes under variable pressure and temperature conditions. Hycal Energy Research Laboratories is the contractor conducting the study which is expected to be completed in 1987 at a cost of $198,500.

## *3.3 AOSTRA-HUDSON'S BAY (DOME) Cessford Caustic Flood Test*

Hudson's Bay Oil and Gas Company Limited, now Dome Petroleum Limited, conducted single-well tracer tests on two wells in the Cessford Basal Colorado "A" Pool in 1980 to evaluate the pool as a candidate for caustic waterflooding. AOSTRA acquired the results of the tests in 1981 which determined that the tracer technique was effective for measuring residual oil saturations before and after a caustic waterflood.

Caustic waterflooding was initiated in selected areas of the pool in 1984. Subsequent laboratory tests indicated that oil recovery would further be improved by the addition of polymer to the caustic flood. The injection of polymer commenced in January 1985 and the injection of the caustic-polymer chemical slug will continue until 1988. In March 1986, an agreement for AOSTRA's participation in the pilot was completed. During the past year the injection of caustic-polymer chemical continued in three selected areas in the pool. The gross costs for the incremental caustic-polymer waterflood pilot are estimated to be $4.9 million.

## *3.4 AOSTRA-INDUSTRY HYCAL Recovery Study of Heavy Oil and Bitumen Using $CO_2$*

AOSTRA was a participant in a multi-client industry-supported project operated by Hycal Energy Laboratories Limited to investigate the effect of $CO_2$ in displacing heavy oil and bitumen. The laboratory study was supported by 14 participants including AOSTRA and completed in 1986. The cost of the study to AOSTRA was $11,500.

## *3.5 AOSTRA-NORCEN Bodo Field Pilot*

AOSTRA and Norcen Energy Resources Limited with Texaco Canada Resources Ltd., Murphy Oil Company Limited, and Canadian Occidental Petroleum Limited are conducting a comparison of steamflooding versus combustion in the

Bodo field in east central Alberta producing from the Mannville "B" sandstone.

A nine-spot steam pilot similar in configuration to the original combustion pattern has been constructed off-setting the combustion operations in the Bodo field. The steam pilot began operations in mid-1985 and continued throughout 1986 with encouraging results. Operations will continue throughout 1987.

### *3.6 AOSTRA-PANCANADIAN Countess "B" Combustion Project*

AOSTRA, PanCanadian Petroleum Limited, and LL&E Canada Limited cooperate in the Countess "B" pilot designed to evaluate a wet combustion recovery process in the waterflooded Countess Upper Mannville "B" pool near Brooks, Alberta. PanCanadian operate and finance the field pilot with LL&E. AOSTRA is funding a research program to support the pilot activities.

Pilot operations were encouraging during 1986 and will continue through 1987. The supporting research program included combustion tube tests, emulsion treating study, geological study, behind-burn core well, corrosion studies, combustion front mapping, numerical modeling and core flow tests for process evaluation. The supporting research program will continue throughout 1987.

### *3.7 AOSTRA-PETROLEUM RECOVERY INSTITUTE Tertiary Recovery Initiative Project*

The Petroleum Recovery Institute (PRI) was contracted by AOSTRA in January 1986 to perform a screening study of all Alberta conventional oil reservoirs to identify prime candidates for possible pilot activity where enhanced recovery was technically feasible. Using a screening program and a ranking system, PRI screened over 3000 reservoirs for 11 enhanced oil recovery processes. A number of pools were identified as potential pilot sites for each enhanced oil recovery process. The study was completed in October 1986 at a cost of $40,000.

### *3.8 AOSTRA-D.B. ROBINSON AND ASSOCIATES INDUSTRY Slim Tube Study*

AOSTRA is the operator of this cooperative industry-supported research program for D.B. Robinson and Associates Limited. The objective of the project is to develop equipment and demonstrate the feasibility of collecting and analyzing small samples of flowing fluids in a slim tube experiment, particularly in the transition zone between oil and solvent. The project commenced in October 1986 and is financially and technically supported by ten companies and AOSTRA.

### *3.9 AOSTRA-VIKOR RESOURCES Joffre Viking $CO_2$ Miscible Pilot*

The Joffre Viking carbon dioxide miscible pilot is located in a previously waterflooded and abandoned segment of the Joffre Viking (Lower Cretaceous) sandstone reservoir in central Alberta. The pilot is operated by Vikor Resources Limited on behalf of AOSTRA and the unit participants. The pilot is testing the ability of a $CO_2$ miscible flood to recover tertiary oil from a three-meter thick previously waterflooded reservoir containing light gravity oil.

The initial pilot consisted of two five-spot patterns each covering 64 ha. $CO_2$ injection commenced at one of the patterns in January 1984 and at the second pattern in July 1984. $CO_2$ injection alternating with water injection (WAG process) for mobility control continued until October 1986. Water injection is being continued in the two patterns. During the last year, a third well was converted to $CO_2$ injection to improve oil recovery near the edge of the reservoir. Production response to $CO_2$ injection was evident during 1984.

The gross cost of the project is estimated to be $16 million and it is planned to operate through 1987. To date, the results of the pilot have been encouraging. A commercial expansion consisting of eight wells in an area off-setting the pilot was completed by the unit owners in 1985.

### *3.10 CANADIAN WESTGROWTH LIMITED Retlaw Upper Mannville "B" Immiscible $CO_2$ Project*

AOSTRA will acquire operating data on the Retlaw Upper Mannville "B" Unit immiscible $CO_2$ project which is located near Lethbridge and operated by Canadian Westgrowth Limited. The objective of this project is to evaluate the performance of a $CO_2$ immiscible flood in a medium-gravity reservoir. The injection of $CO_2$ commenced in October 1983. $CO_2$ is being supplied to the project from the nearby Turin gas plant and was supplemented by trucked liquid $CO_2$ from nearby fertilizer plants. This is the first immiscible $CO_2$ flood to be conducted in Canada.

## 4 Produced Water Recycling Program

### *4.1 Produced Water Treatment Pilot at Shell Peace River Project*

When the AOSTRA/Industry Produced Water Treatment Project was terminated in 1985 due to the economic downturn of the oil industry, Shell Canada Limited continued to examine produced water treatment alternatives. Shell operates a steam-assisted in situ bitumen recovery plant in the Peace River area, and requires a process to provide high quality boiler feedwater from the water co-produced with the bitumen.

AOSTRA and Shell are now working to field test a water treatment scheme proposed by Shell which consists of oil removal and ion exchange softening, but which does not treat the water to levels of purity recommended by boiler manufacturers. A small test boiler of the horizontal tube once-through design is being manufactured as part of the pilot, and the performance of the boiler will be monitored when operated on the treated water.

Construction of the skid-mounted pilot plant is underway, with on-site delivery expected by mid-year 1987. The pilot will

be in operation for approximately one year, with the final report expected by late summer of 1988. AOSTRA is contributing 35% of the $2 million project cost.

### *4.2 Lindbergh Area Produced Water Treatment Project*

In the fall of 1986, AOSTRA joined with Environment Canada and five industrial companies, each of whom hold leases in the Lindbergh area of Alberta, to undertake a field test of a produced water treatment scheme tailored to the needs of Lindbergh area produced water derived from in situ recovery of heavy oil.

When the AOSTRA/Industry Produced Water Treatment Project ended in 1985 due to the economic downturn of the oil industry, each of the industrial participants reviewed the final recommendations. A common problem for all companies using steam stimulation in the Lindbergh area is the extremely high level of total dissolved solids (TDS) found in the water co-produced with the bitumen. A project was proposed to test the efficiency and operating characteristics of a vapor compression evaporator for TDS removal. The test program will also examine the corrosion in the evaporator, and the filtration requirements upstream of the evaporator.

The project has an estimated cost of $750,000 with 50% AOSTRA funding and approximately 26% funding by Environment Canada. The remainder of the project costs are being covered by the industrial participants. The six-month evaporator test program is scheduled to begin in June of 1987, with a final report due by spring of 1988.

## 5 Surface Mining/ Extraction Program

### *5.1 TACIUK Direct Thermal Processor*

With the downturn in oil prices and the consequent difficulty in attracting industry participation in new oil sands technology development, during the past year, the focus of development of the Taciuk Process centered on alternate uses.

The Taciuk Process is a dry retorting process that has been under development since 1977 by AOSTRA and UMATAC Industrial Processes Ltd., a division of UMA Engineering Limited, for the simultaneous extraction and primary upgrading of oil sands bitumen. Since 1977, total project expenditures have amounted to approximately $15.7 million. All of the development costs have been provided by AOSTRA.

Two specific non-oil sands applications which have generated a substantial degree of interest are the processing of oil shales and the treatment of hydrocarbon-bearing waste materials such as oil contaminated soils.

In mid-1986, a series of extensive batch tests were carried out in the pilot plant facilities located in Calgary, Alberta, to examine the processability of Australian oil shales. In this program, the critical process operations which consist of feed drying, feed preheating, thermal retorting, and combustion of laid down coke were investigated in specially designed equipment to simulate actual unit operations. Based on the favorable results from this test program, AOSTRA and an Australian company have negotiated the principles of an agreement under which a 2000 tonne sample of shales from the Stuart deposit in Queensland, Australia, will be tested in the continuous flow pilot plant located in the AOSTRA facilities in Calgary. If the pilot test is successful, this company will undertake detailed engineering and cost studies to determine the feasibility of constructing and operating a Taciuk Process demonstration plant in Australia.

The Taciuk Process has shown promise as a method by which hydrocarbon bearing solid wastes, such as oil contaminated soils, can be effectively treated to yield an oil-free solid suitable for use as clean fill, together with thermally cracked oil, non-condensable hydrocarbon gases and flue gas. Tests on a wide variety of waste materials have been performed by UMATAC with satisfactory results. The commercial market for efficient waste treatment technology is attracting significant interest among remedial action contractors in both Canada and the USA. Companies in both countries are currently negotiating terms for commercial licenses to use the Taciuk Process for oily waste treatment applications.

### *5.2 Coke Desulfurization Project*

In a development arising from a previous direct oil sands retorting project funded by AOSTRA and Canstar Oil Sands Limited, Nova/Husky Research Corporation Limited has been retained to test the effect of adding calcium to the oil sands to remove sulfur. Calcium carbonate was added to the oil sands prior to the coking stage and the sulfur captured during coke burning was measured.

AOSTRA and Canstar are interested in the possible application of this technology to coke laid down on the sand during thermal retorting of the oil sands, as is the case in the Taciuk Direct Thermal Processor. Limestone from several Alberta sources including samples from the Fort McMurray region were characterized for reactivity, and the most reactive was used for further testing. The effects of limestone particle size, calcium-to-sulfur ratio, and coke burning temperature have been investigated. It has been determined that the calcining characteristics of the limestone have a direct bearing on the residence times and combustion temperatures required for efficient sulfur capture. The project results will be fully presented in the final report which is due in June of 1987. This program began in early 1986, and has a budget of $176,000 which is being funded 95% by AOSTRA and 5% by Canstar Oil Sands Limited.

### *5.3 Dravo Solvent Extraction Process*

In 1985, Dravo Engineers, Inc. prepared for AOSTRA a design and cost estimate for the application of the Dravo Solvent Extraction Process to the recovery of bitumen from an Athabasca oil sands mining operation. The Dravo process is

based on their continuous, rotary, percolation-type solvent extractor. The study that Dravo prepared was based on a pilot scale of 200 t/day feed of 11.6 wt% bitumen. Dravo also included an extraction-only conceptual commercial design based on a 67,000 t/day feed rate of similar ore.

AOSTRA conducted an in-house comparative economic evaluation of the Dravo and hot water extraction processes, involving integrated mining, extraction, and upgrading facilities. The evaluation estimated that both the capital and operating costs of a Dravo-based mining operation are significantly higher than those of a hot water extraction-based operation. Subsequent to the in-house evaluation, AOSTRA chose not to participate in any further development of the Dravo process.

### *5.4 Solv-Ex Solvent/Water Extraction Process Development*

AOSTRA and Shell Canada Limited have agreed to fund, on a 50-50 basis, a $6 million project to determine the applicability, efficiency, and costs to extract bitumen from mined oil sands using the Solv-Ex Process.

The "Solv-Ex Process" is essentially a hot water-assisted solvent extraction process. The feed oil sands is mixed with water and solvent in a staged counter-current process circuit. The process discharge streams are bitumen product and solids with the solvent being recovered for reuse. The project consists of two phases. Phase I consisted of a test run program using a 1 t/hour pilot located in Albuquerque, New Mexico, from June 1986 through February 1987. Twelve hundred tonnes of oil sands feed material were shipped to Albuquerque from Shell's lease near Fort McMurray, Alberta. Final reports for the Phase I work are scheduled to be completed by August 1987.

Phase II, in which AOSTRA has an option to contribute additional funding, is an economic feasibility study for a demonstration plant to be located on Shell's lease. Phase II is scheduled to be completed by September 1987.

### *5.5 Recovery of Oil From Tailings Sludge*

AOSTRA and Suncor Inc. have funded, on a 75-25 basis, respectively, the Oleophilic Sieve Development Company of Canada Limited (OSDCL) to test and develop the Oleophilic Sieve Process (the Kruyer process) for extracting hydrocarbons from the tailings sludge produced by the hot water extraction of bitumen from mined oil sands.

The Kruyer Process is a novel extraction concept which uses an oleophilic sieve wrapped around an apertured drum that is partly filled with oleophilic balls. The oleophilic balls strip and agglomerate the bitumen from the sludge feedstock which is then captured on a coated surface of a perforated sieve, while water and solids are allowed to pass through the sieve openings.

The project consisted of two phases. Phase I entailed engineering, procurement, construction, and performance testing of a 1 t/hour continuous pilot plant in Edmonton and was completed in May 1985 at a total cost of $740,000.

Phase II entailed skid mounting the existing pilot and relocating it to the Suncor plant site near Fort McMurray for extended testing on various sludge streams. Phase II testing was completed in November 1985 and cost $400,000.

Phase II results showed that hydrocarbons can be extracted from the hot water extraction process tailings sludge. Further test work will be required to identify and quantify the key scale-up design parameters.

Further development work in 1986 has not been undertaken due to the lack of industrial participation resulting from the economic slowdown in the petroleum industry.

### *5.6 Overburden Dredging Pilot at Syncrude*

It was about ten years ago that AOSTRA initiated studies in overburden dredging in order to reduce the costs of removal of overburden prior to the mining of oil sands. The following work has been accomplished:

1. In 1977/78, AOSTRA commissioned two studies by H.G. Stephenson (Mining) Consultants Ltd. to provide an economic comparison of dredging and conventional strip mining.

2. From 1980 through 1983, AOSTRA funded laboratory studies by Dr. M.B. Dusseault of the University of Alberta to evaluate problems inherent in dredging fine grained Clearwater clays normally found in the Fort McMurray area.

3. In 1982, AOSTRA joined Petro-Canada in a test program at Delft Hydraulic Laboratory, Holland. This program used a laboratory dredge to dig and pump oil sands and clay materials.

In 1985, AOSTRA and Syncrude Canada Limited agreed to finance a larger scale field program, which all earlier research had indicated, was a mandatory next step. The focus of this program was on disposal of the dredged material. The test was conducted in August and September 1985. The machine used was supplied by Sceptre Dredging of Vancouver, who modified a standard 16 inch dredge for higher digging and pumping forces. Even with the modifications, the dredge had difficulty digging in situ Clearwater and Pleistocene clays. Production totaled 7000 bench cubic meters (BCM) out of 40,000 BCM planned. The test did show that the overburden could be dredged and spoiled (discharged and stacked in a slope) with fewer geotechnical problems than anticipated. The 1985 program cost $2.3 million, with AOSTRA contributing $1 million.

The objectives of the 1986 program were to evaluate the spoil performance with higher digging and pumping rates, and to use this data to conduct a feasibility study for commercial scale dredging.

Overburden was excavated, screened to remove oversize material (primarily boulders and siltstone) and recompacted into a bank across the dredge pond. All of the objectives of the 1986 program were achieved. The dredge excavated over 18,000 BCM of the rehandled material at rates of about 250 BCM per hour. The feasibility study was conducted by Beaver Dredging of Calgary.

The results of the 1986 program were:

- In situ overburden can be dredged, but at lower than usual production rates.
- Dredged in situ overburden can be successfully spoiled, provided the build-up of clay fines in the dredging fluid can be controlled.
- Higher dredging rates (with rehandled spoil) and consequent high water recycle rates led to a rapid fines build-up in the water.
- Dredging with high fines fluid would require some extraordinary geotechnical measures to ensure spoil stability.
- A fines ripening pond to allow settling of the clay fines would be required for commercial scale dredging.
- Both the capital and operating costs of a commercial dredging operation were found to be relatively higher than anticipated, approaching the costs incurred with conventional stripping.

After careful review, Syncrude decided that further development work on dredging overburden on their lease was not justified at this time.

The 1986 program cost $1.6 million, with AOSTRA contributing 50%.

### *5.7 OSLO Oil Sand Dredging Test*

In June 1986, in conjunction with the Syncrude Overburden Dredging Program, a small oil sands dredging experiment was conducted by OSLO and AOSTRA. OSLO is a consortium consisting of Esso Resources Canada Limited, Canadian Occidental Petroleum Ltd., Gulf Canada Corporation Inc., Petro-Canada Inc., Alberta Oil Sands Equity, and PanCanadian Petroleum Limited.

The purpose of the test was to evaluate the dredging and pumping of oil sands as a conditioning device for OSLO's cold water oil sands extraction process.

Over a two-day period, more than 500 m³ of rehandled oil sands were dredged and spoiled in three distinct tests, using separate spoil areas. The main variant in the test program was the amount of air injected in the pipeline used to transport the dredged oil sands to the spoil ponds.

The test showed that there was considerable potential for using dredging and pumping as both a mining and conditioning device. OSLO was able to demonstrate adequate recoveries using simple chemical addition and flotation.

The 1986 program cost $60,000, with AOSTRA contributing $30,000.

OSLO and AOSTRA are currently evaluating an extended follow-up program for 1987 and beyond, which would lead to the evaluation of commercial oil sands dredging on OSLO's lease.

## 6 Upgrading Program

### *6.1 Upgrader Demonstration Project*

AOSTRA has been working on joint studies with industry on improved upgrading technology. The Heavy Oil Upgrading Study completed in 1983 indicated the potential for high conversion hydrocracking processes to provide improved economics due to higher yields and lower costs.

In 1986, in the Upgrading Demonstration Project-Phase II, specific projects were defined which could demonstrate the commercial viability of three selected upgrading processes: CANMET hydrocracking; high conversion H-Oil; and VEBA Combi-Cracking (VCC). Participation in these tests was proposed in February 1986, but companies were unable to contribute funding due to severe budget constraints caused by low oil prices.

AOSTRA then worked independently with the process licensors to define lower-cost projects. In 1986, agreements were reached with two process developers to fund demonstration tests: the VCC feed test with VEBA OEL; and the High Conversion H-Oil Test with Hydrocarbon Research Inc. In both cases the tests were designed to demonstrate the performance of the selected process through the operation of existing licensors' pilot plants on Alberta feedstocks. The information obtained will provide the required design information for commercial application of the processes in Alberta.

### *6.2 High Conversion H-Oil Test*

In November 1986, AOSTRA agreed to provide $1.7 million for a demonstration of the High Conversion H-Oil Process. This is an extension of the commercially proven H-Oil ebullated bed catalytic hydrocracking process to higher severity operation where over 90% of the non-distillable residues are converted to products. The key to achieving high conversion with the H-Oil Process is the use of vacuum bottoms recycle.

The tests on Cold Lake bitumen were carried out in a 5 m³/day process development unit in Lawrenceville, New Jersey. Pilot plant operations were successfully completed in January 1987, following an uninterrupted six-week run. Successful operation for three weeks at 92% conversion using an equilibrated catalyst demonstrates that the H-Oil process can operate at high conversion on Alberta feedstocks. This mode of operation, called high conversion hydrocracking, has been shown in studies performed for AOSTRA and others as having better economic potential than lower conversion processes.

### *6.3 VEBA Combi-Cracking (VCC) Test*

In September 1986, AOSTRA agreed to pay 80% of the cost of a $4.6 million test of the VCC process. The VCC Process is a high conversion hydrocracking process which combines thermal hydrocracking in a liquid phase reactor with catalytic hydrotreating in a gas phase reactor.

The objective of the test is to demonstrate the performance of the VCC process on an Alberta feedstock, specifically Cold Lake bitumen. Over 1600 m³ of diluted bitumen were shipped to Europe, for distillation in Antwerp and processing in the VEBA OEL pilot plant in Gelsenkirchen, West Germany. Feed preparation is complete and the test is scheduled for May and June 1987.

### *6.4 AOSTRA/Gulf Donor Refined Bitumen Project*

AOSTRA has been working with Gulf Canada Corporation Inc. since 1983 on the development of the Donor Refined Bitumen (DRB) Process. This process for upgrading bitumen involves thermal cracking and liquid phase hydrogenation using a process derived donor solvent. Following the successful development using the Gulf pilot plant at Sheridan Park, Ontario, AOSTRA and Gulf joined with the French group, ASVAHL, to demonstrate the process at the research refinery built by ASVAHL near Lyon, France. ASVAHL, an acronym for "Association Pour la Valorisation des Huiles Lourdes", or the Association for Heavy Oil Upgrading, has Institut Francais du Petrole (IFP) and the French oil companies ELF and Total as equal partners. For the demonstration test, AOSTRA, Gulf, and ASVAHL provided equal contributions to the project in either funding, technology, or facilities. AOSTRA provided $10.8 million for the demonstration test in addition to the $1.6 million for the earlier phases of the development at Sheridan Park. In the fall of 1986, over 2000 $m^3$ of Athabasca bitumen were shipped to France. This was prepared in April and May 1986, for the demonstration program. Over the summer, the ASVAHL refinery was modified to operate as the DRB Process. The test program was started in October and ran through to mid-December 1987.

The test results are now being evaluated. Preliminary results show the basic DRB process was confirmed. Eight balance periods were obtained at residue conversions ranging from 50% to 75%. Yield of liquid products and donor self-sufficiency were better than expected. Solids accumulating in process vessels prevented the demonstration of long-term operability. These solids, clay and coke, built up at a rate many times that experienced in the pilot plant. Further work is required on a modified reactor design to fully demonstrate the process.

### *6.5 TOYO Engineering Corporation*

In 1986, AOSTRA funded TOYO Engineering Corporation in the amount of $196,500 to demonstrate the HSC/ROSE® process for upgrading Cold Lake bitumen. This process involves thermal cracking in a soaker (HSC) followed by solvent extraction of the HSC residue using Kerr-McGee's ROSE® process. The tests in the HSC pilot plant were completed in January 1986 and the extraction tests using the ROSE® process were completed in the spring of 1986. The final report on both the tests and an engineering evaluation on a 3200 $m^3$/day plant were received in December 1986.

The test objectives were achieved. The success of the test program shows that the TOYO HSC/ROSE® process is applicable to the upgrading of Alberta feedstocks.

### *6.6 AOSTRA/Industry Upgrading Residue Utilization Project*

One important factor in the choice of upgrading technology is the successful utilization of any residues produced by the process. The form, quantity, and quality of these residues (pitch or coke) can affect the cost and complexity of the overall upgrading plant. In 1982, AOSTRA initiated a study on Upgrading Residue Utilization with the Federal Department of Energy, Mines and Resources and eight industrial companies. Phase II of this study was completed this year with an evaluation of the report and recommendation for pilot tests on selected residues and utilization technologies.

Because of budget constraints for AOSTRA and industry participants, the comprehensive test program was deferred and a limited Phase III Initiation Project was proposed in March 1987, at a cost of $260,000. This program would undertake preliminary work such as procurement of pitch, analytical tests, and small-scale combustion tests.

## 7 University Program

### *7.1 Professorships*

In the past twelve years, AOSTRA has appointed eleven professors to Professorships at Alberta universities to carry out advanced research on oil sands problems. The term of each initial appointment is three years renewable for a further term of two years. The incumbent professors may also apply for additional funds for specific research projects.

The current incumbents are involved in the following research projects:

1. Dr. J.W. Costerton of the University of Calgary (AOSTRA professor, 1985 - 1987) will be investigating the use of bacteria ultramicrocells as a method of preventing coning and improving flow paths of fluids in high permeability zones in conventional and heavy oil reservoirs.

2. Dr. L.G. Hepler of the University of Alberta (AOSTRA professor, 1978 - 1987) is continuing his investigation of clay/oil/water systems encountered in many aspects of the oil sands industry and is also measuring specific heats of various components of oil sands and heavy oil deposits.

3. Dr. O.P. Strausz of the University of Alberta (AOSTRA professor, 1981 - 1987) is continuing the investigation of the chemistry of Alberta oil sands bitumens, with particular emphasis on the heavier fractions.

4. Dr. E.L. Tollefson of the University of Calgary (AOSTRA professor, 1982 - 1987) continues the investigation of desulfurization of coke and the relative fuel values of some constituents of oil sands.

These professors devote approximately three-fourths of their time to oil sands research. The total funding committed to date for the Professorship program is $4.0 million.

AOSTRA is currently reviewing this program and changes are expected to be announced in 1987.

### *7.2 Graduate Scholarships and Fellowships*

Post-graduate scholarships and fellowships have been made available over a ten-year period for oil sands research at the University of Alberta, the University of Calgary, and the University of Lethbridge. Current award holders are identified in the following lists. The scholarships are for a maximum period of two years and the research carried out will normally lead to either a Masters or Doctoral degree. Fellowships are intended to assist post-doctoral scientists in furthering their research training. Many of these individuals will eventually enter the industrial research sphere.

**University of Alberta**

| | |
|---|---|
| Branco, P. | Medeley, R.A. |
| Coskuner, G. | McBain, C. |
| *Foght, J.M. | McKay, J.E. |
| Kasperski, K.L. | Sarma, H.K. |
| Le, H. | Semple, K.M. |
| Macrides, C. | Zelt, B.W. |

**University of Calgary**

| | |
|---|---|
| Abercrombie, H.J. | Nighswander, J.A. |
| Belgrave, J.D.M. | Sengupta, S. |
| Chung, K.H. | Sibbald, L.A. |
| Kirk, M.J. | Sim, K.L. |
| *McKinley, V.L. | Tompkins, B. |
| Mehta, S.A. | Wozniak, W. |

*Fellowship

### *7.3 University Research Program*

AOSTRA continues to support varied oil sands and heavy oil-related research projects at Canadian universities. The university research program covers many areas of practical interest ranging from fundamental research to new process development for the recovery and upgrading of bitumen and heavy oil. The budget in 1986/87 for support of research in Canadian universities amounted to approximately $2.8 million. Brief descriptions of the projects carried out in 1986/87 follow:

1. Dr. H. Alper of the University of Ottawa completed his research on new, mild, and economical methods for extracting sulfur from bitumen. Two promising heterogeneous catalysts were identified. A total of $68,000 was made available for this project over 18 months.

2. Dr. D.W. Bennion and Dr. R.G. Moore of the University of Calgary are continuing their extensive investigation of combustion in oil sands and the low temperature oxidation of bitumen. These researchers have been funded over a period of 11 years for a total of $1,918,764.

3. Dr. N. Berkowitz of the University of Alberta completed his study of bitumen extraction from oil sands by using supercritical gas in H-donor systems. Funding of this project amounts to $96,740 over two years.

4. Dr. B.D. Bowen and Dr. S. Levine of the University of British Columbia have been using theory and experiment to identify the mechanisms by which fine particles and clays stabilize emulsions. This project was funded to the amount of $172,416 over 30 months.

5. Dr. P.M. Boorman, Dr. R.A. Kydd, and Dr. T.S. Sorenson of the University of Calgary are developing hydrocracking catalysts capable of being used under mild conditions, to enhance the yield of liquid products with low aromaticity. This work and earlier studies by Dr. Boorman have been funded at $606,031 since 1976.

6. Dr. R.M. Butler of the University of Calgary is investigating heat and mass transfer mechanisms important to processes of in situ recovery of bitumen. Funding of Dr. Butler's work amounts to $582,500 over four years.

7. Dr. R.G. Cavell of the University of Alberta is applying Secondary Ion Mass Spectrometry (SIMS) to study the interaction of polar organic and inorganic molecules with mineral surfaces such as those found in tailings of the hot-water process. The amount of funding is $151,410 for a three-year period.

8. Dr. F.S. Chute and Dr. F.E Vermeulen of the University of Alberta have been measuring electrical properties of oil sands, developing physical models of electrical heating processes, and evaluating the use of electrical power for selective heating of oil sands. Their research has been funded to the amount of $537,663 over a period of nine years.

9. Dr. J.W. Costerton of the University of Calgary is investigating the use of bacterial microcells as injection agents to prevent coning and to improve conformance by selectively plugging high permeability zones. A total of $442,000 has been allotted to this and earlier projects over five years.

10. Dr. J.E. Desnoyers of the University of Sherbrooke is studying phase equilibria and other properties of oil-water microemulsions, with the objective of using microemulsions for the extraction of bitumen and heavy oil. Funding for this work amounts to $391,170 over seven years.

11. Dr. F.A.L. Dullien of the University of Waterloo completed his project to investigate pore structure, rock-fluid interactions, and two-phase flow behavior in cores obtained from the Pembina Cardium A-Pool. This project has been funded to the amount of $47,492 for two years.

12. Dr. M.B. Dusseault of the University of Waterloo began a new project to delineate the volume and permeability changes that occur under the low shear stress conditions that accompany high pressure injections during in situ recovery. This four-year study is funded at $210,956. Funding of previous geotechnical and geomechanical studies by Dr. Dusseault amounts to $79,551 over five years.

13. Dr. Z. Eisenstein and Dr. J.D. Scott of the University of Alberta are modeling the response of oil sands to shaft sinking and tunneling. This one-year project is funded at $79,999.

14. Dr. S.M. Farouq Ali of the University of Alberta is studying the use of small amounts of carbon dioxide gas to improve the waterflooding process for recovery of Alberta light oils, developing new methods of mobility control that will improve recovery of heavy oil or bitumen from the Athabasca and Lloydminster deposits and constructing a computer program to model formation

fracturing and recovery during steam-injection operations. Funding of these projects amounts to $979,470 over eight years.

15. Dr. J.E. Gillott of the University of Calgary has completed his investigation of the changes in strength, dimensions, permeability, and bonding characteristics of oil well cements after hydrothermal treatment in the presence of formation fluids and drilling muds. This is a seven-year project amounting to $238,349.

16. Dr. M.R. Gray and Dr. I.G. Dalla Lana of the University of Alberta are developing methods to characterize the kinetics of refining processes in terms of the functional groups of the components of bitumen feedstock. This five-year project has been funded in the amount of $350,000.

17. Dr. L.G. Hepler of the University of Alberta is measuring the colloidal properties of various clay/oil/water systems, primarily for application to water and tailings treatment. He is also measuring the thermodynamic properties of bitumen/gas systems and the kinetics of bitumen oxidation, to obtain quantitative relationships useful in modeling in situ recovery processes. Funding has amounted to $787,004 over ten years.

18. Dr. T.R. Hsu of the University of Manitoba is developing a computer program to model high-velocity fracturing of oil sands for application to processes used to generate interwell communication paths. Laboratory experiments are underway to test and refine the program code. This four-year project costs $316,300.

19. Dr. I.E. Hutcheon of the University of Calgary is conducting laboratory work and field studies to characterize the dissolution and precipitation of minerals in thermal processes for recovery of bitumen. Funding of this seven-year project amounts to $539,290.

20. Dr. J.B. Hyne of the University of Calgary is studying the chemical reactions in bitumen that cause gas to be produced as a reservoir is steamed, and their effects on the physical properties of the bitumen. The cost of this two-year project will be $198,270.

21. Dr. F.W. Jones and Dr. J.S. Rogers of the University of Alberta are developing an improved meter to measure tilt of the surface induced by a recovery process. This instrument is potentially useful for monitoring the progress of in situ recovery processes and is being tested at the GLISP site. This seven-year project cost $325,268.

22. Dr. G. Karim of the University of Calgary is investigating the processes of ignition, flame propagation, and quenching in low velocity streams of fuel in vapor-air mixtures in porous media. This three-year project is funded at $156,920.

23. Dr. P. Lancaster of the University of Calgary has completed a project to develop computer algorithms for problems in geophysical tomography and in the application of inverse scattering methods. Funding of this one-year project amounts to $38,810.

24. Dr. B.C.Y. Lu of the University of Ottawa is conducting laboratory experiments to measure phase equilibria of mixtures of water and bitumen under the conditions obtained in steam processes. Also, Dr. Lu is examining the internal consistency of existing data on gas solubilities in bitumen which are available to AOSTRA. Funding amounts to $176,900 over five years.

25. Dr. A.K. Mehrotra and N.E. Kalogerakis of the University of Calgary are attempting to measure and model the distribution of carbon dioxide between oil and brine under in situ recovery conditions. $133,300 is allotted to this project over three years.

26. Dr. N.R. Morgenstern and Dr. J.D. Scott of the University of Alberta are measuring the strength, deformability, and permeability of oil sands at the high temperatures and pressures that are found in in situ thermal processes. The objective is to develop a geomechanical model for reservoir assessment. This work and earlier studies by these researchers have been funded to a total of $1,074,250 over an eight-year period.

27. Dr. E. Kanasewich and Dr. E. Nyland of the University of Alberta are developing and testing algorithms that interpret signals received by geophones to monitor and locate sources of microseisms induced by in situ processes. Total funding of $896,864 has been allocated for this and earlier work, over an eight-year period.

28. Dr. S.G. Pemberton of the University of Alberta is studying the ichnological microdynamics of the Athabasca oil sands. Traces of the fossil workings of worms provide good paleontological control and facies predictive capabilities beyond the borehole. Funding for this two-year project is $136,265.

29. Dr. D.Y. Peng of the University of Saskatchewan is analyzing the application of continuous thermodynamics to develop improved equations of state for bitumen/gas systems. A total of $28,960 is budgeted for this one-year project.

30. Dr. R. Puttagunta of Lakehead University is developing general correlations to predict the viscosity of bitumen gas mixtures in all Alberta oil sands formations under in situ recovery conditions. The project is funded at $40,000 over a two-year period.

31. Dr. L.W. Reeves of the University of Waterloo has completed a project to investigate the application of nuclear magnetic resonance spectroscopy to determine physical and chemical properties of oil sands and bitumen. This two-year project cost $30,000.

32. Dr. R.S. Roche of the University of Calgary has completed a project to investigate the kinetics of the pyrolysis of bitumen. Dr. Roche has developed an analytical procedure, non-isothermal programmed pyrolysis-mass spectrometry (NIPPY-MS), for identifying the thermo oxidative changes in asphaltenes and other components of bitumen in produced fluids from in situ combustion pilots. This project has been funded to the amount of $1,027,730 over ten years.

33. Dr. C. Scarfe of the University of Alberta is measuring the dissolution

kinetics of calcite and dolomite mineral under in situ recovery conditions, for application to modeling reservoir fluid chemistry. $94,095 is budgeted over three years.

34. Dr. F. Seyer of the University of Alberta is analyzing the effect of mass transport phenomena in the hot water recovery process. This one-year project is budgeted at $30,560.

35. Dr. T.J.T. Spanos of the University of Alberta is developing mathematical expressions that describe the flow of mixtures of oil and water through sand, the gravity drainage process, and the propagation of sound through an oil sands deposit. This research cost $354,383 over seven years.

36. Dr. O.P. Strausz and Dr. D.S. Montgomery of the University of Alberta have been conducting several continuing in-depth research projects to characterize different aspects of the chemistry of bitumen. These involve: the identification and quantification of compound types and geochemical markers, studies on the chemical and thermal degradations of asphaltenes and resins, and the influence of various catalysts on these processes, identification of the causes of poor separability of some bitumens, and the design of new upgrading technology. Total funds spent and committed in the period 1977 to 1989 amount to $2,971,693.

37. Dr. W.Y. Svrcek and Dr. A.K. Mehrotra of the University of Calgary have completed a series of projects to measure the solubilities of gases in bitumen and the viscosities of the resulting gas-bitumen solutions. Total funding since 1976 has been $584,647.

38. Dr. T.W. Swaddle of the University of Calgary is using nuclear magnetic resonance techniques to identify the dissolved silicate and aluminosilicate species that form under conditions in which formation minerals dissolve and precipitate during in situ recovery. Funding of $50,322 was allotted to this one-year project.

39. Dr. E.L. Tollefson of the University of Calgary is investigating the technology of upgrading coke, pitch, heavy oil, and bitumen. This work and earlier studies on methods of coke desulfurization have been funded at a level of $753,370 over nine years.

40. Dr. J.K.S. Wan of Queen's University is investigating the use of microwave heating of dilute catalysts to hydrocrack fractions of bitumen. Also, Dr. Wan is improving his similar process developed earlier for AOSTRA to generate olefins from methane and other alkanes. Total funding is $420,104 for five and one-half years.

41. Dr. N.C. Wardlaw of the University of Calgary is investigating rock-pore properties in carbonate and sandstone reservoirs important to enhanced oil recovery processes. This project is funded for $367,384 over a four-year period.

# 8 AOSTRA-Alberta Research Council Program

AOSTRA continues to fund several major research programs at the Alberta Research Council (ARC). These programs are briefly described below.

### *8.1 Oil Sands Laboratory Research*

Since its inception in 1981, the AOSTRA/ARC Joint Oil Sands Research Program has developed a technology and expertise base composed of both trained personnel and advanced technical hardware. Both data and process concepts developed in the program are being applied in the field. In order to facilitate transfer of technology to field application, a new five-year arrangement between AOSTRA and ARC commenced immediately after the previous five-year joint program expired on March 31, 1986. Under the new agreement, the joint program has been restructured forming two programs: a "Core Program" and a "Strategic Program". The Core Program will:

- focus on regional generic problems;
- investigate fundamental reservoir mechanisms;
- evaluate and verify novel concepts;
- support long-term technology development.

The Strategic Program will:

- be mission-oriented and focus on site-specific problems;
- further develop promising process concepts from the Core Program and the university program;
- focus on process development for field application;
- support short- and medium-term needs;
- evaluate innovative process concepts from other sources.

In support of these new thrusts, new programs have been developed with important contributions from industry access member companies, from field pilot operations, and from AOSTRA and ARC staff members.

In 1986/87, five technical projects were carried out under the core program, namely:

- Process flow mechanisms
- Communication development and conformance control
- Advanced process development
- Near well and production-related studies
- Supporting research (to continue to develop the technical tools and the theoretical base required to support and advance the research activities of the program).

Approximately $4 million was expended during the first year of the new five-year Core Research Program. AOSTRA contributed one-half of the total cost, ARC the remainder.

The Strategic Program is also carried out by ARC staff and is 100% supported by AOSTRA and provides a confidential environment within which applied proprietary research and development can be undertaken. 1986/87 was the first year

of the Strategic Research Program. Only project proposals of priority received approval within the stated $1.5 million budget. AOSTRA's priorities were continually monitored by the program committee during the year resulting in one project being shelved, and other projects being modified appropriately.

Partly as a result of this continuous assessment of both project content and relevance, the first year of the program was very successful. For example, the following seven invention disclosures have emanated from these projects and have been submitted for possible patent application.

1. A method to create high permeability, water-saturated deep penetrations, in an oil sands formation.

2. A novel well completion technique and associated perforation sand-in preventer.

3. A method to increase injectivity and permeability along a perforated well in oil sands reservoirs.

4. In situ methods for recovering viscous oil from an oil sands or heavy oil formation. (A)

5. In situ methods for recovering viscous oil from an oil sands or heavy oil formation. (B)

6. Method of recovering viscous petroleum from an oil sands substrate "cold-hot" process.

7. The application of solvent dispersions as communication enhancing agents.

### *8.2 Regional Geological Study*

Since late 1979, the regional geological investigations of Alberta's oil sands and heavy oil deposits have produced an extensive data base and geological expertise unique both within Alberta and beyond. Furthermore, the staff which has been assembled through this program has provided significant technical contributions to geological problems associated with AOSTRA-supported pilot projects.

To capitalize upon the existing geological expertise, a new strongly-focused five-year oil sands geology program (1986 - 1991) has been developed and consists of two major elements:

1. *Joint Program:* (a) funded on an equal, tripartite basis by AOSTRA, Alberta Department of Energy, and ARC, with each agency contributing $400,000 per annum; and (b) focused on resource characterization and detailed geological reservoir studies.

2. *Strategic Program:* (a) funded 100% by AOSTRA with a budget of approximately $200,000 for the first year of the program; and (b) designed to address specific proprietary geological concerns of AOSTRA in areas of resource evaluation, pilot siting, operational strategy, and process-reservoir compatibility.

In 1986, AOSTRA and ARC jointly sponsored a series of workshops on each of the major oil sands deposits and heavy oil belt for companies involved, or interested in, thermal recovery for in situ pilot projects. The workshops dealt with the geological parameters which can affect pilot siting and operating strategy and were followed by a major geology forum.

### *8.3 Hydrocarbon Upgrading Project*

This is the final year of the three-year agreement between AOSTRA and ARC for developing a research capability in Alberta on upgrading of bitumen and conducting bench-scale and pilot-scale experiments that develop promising processes discovered in other AOSTRA-supported research. The project is supported equally by AOSTRA and ARC with an annual budget of $1.5 million.

Major achievements during the final year of the project include the following:

- Commissioned the tubular reactor system.
- Collected yield and product quality data using the continuous tubular reactor system on the coal-bitumen co-processing concept.
- Completed catalyst regeneration and coking studies.
- Undertook some exploratory research in improving asphaltene conversion, non-catalytic removal of nitrogen compounds from naphtha fraction, and methods of improving hydrocracking and hydrotreating catalysts' efficiencies.

### *8.4 Sample Bank*

AOSTRA continues to support up to 2.4 person-years of effort each year at ARC for the Sample Bank project. The prime function of the Sample Bank is to provide "standard" oil sands, bitumen and other related samples to research workers around the world. In the year ending March 31, 1987, 124 shipments were made. A total of 52.1 tonnes was shipped and generated $76,106.50 income.

## 9 Programs at Other Research Organizations

### *9.1 Syncrude Canada Limited*

AOSTRA has collaborated with Syncrude Canada Limited on the development of a computerized regional Air Quality Prediction System (AQPS), which will give an early warning when impending weather conditions are conducive to high ground-level $SO_2$ concentrations within a 50-km radius of the plant. Once every hour, the AQPS forecasts air quality at each of the five Air Monitoring Network (AMN) stations. The AQPS also predicts the location and magnitude of the constantly moving point of maximum Ground Level Concentration (GLC) under the plume and estimates the extent of the plume's "footprint". Syncrude has designed, built, and installed an automated real-time measurement and computation system at its plant.

The project was completed in November 1986 within the original budget of $2.4 million. AOSTRA contributed one-third of the project cost ($797,400) and has the responsibility to market the technology.

### *9.2 Computer Modeling Group*

AOSTRA and the Computer Modeling Group (CMG) entered into an agreement on April 1, 1986 to develop two advanced thermal simulators, namely:

- Thermal Wellbore Simulator (THEWS)

- Steam-Additive Reservoir Simulator (STARS)

In 1986/87, AOSTRA supported CMG to the extent of $220,000 which is equivalent to two person-years of effort for developing these two simulators and providing thermal simulation support to AOSTRA. AOSTRA obtains ongoing access to and royalty-free use of all CMG models while development is in progress.

### *9.3 Petroleum Recovery Institute*

The research program at PRI continued to be supported by AOSTRA during the current year by funding which matched industry membership contributions. The AOSTRA grant for the 1986/87 fiscal year totalled $1 million.

There are four major research activities currently underway at PRI in the area of Enhanced Oil Recovery Technology. Results of this work are available to industry as well as AOSTRA for potential application.

## 10 International Program

### *10.1 AOSTRA/China Relationship*

In response to an invitation from the Chinese Ministry of Petroleum Industry, AOSTRA formed a delegation of six to visit China's heavy oil development in April/May 1986. The delegation included personnel from AOSTRA's staff, the Alberta Research Council, and the private sector. This visit pertained principally to AOSTRA's cooperative programs with the Research Institute of Petroleum Exploration and Development (RIPED) in Beijing; the Xinjiang Petroleum Administrative Bureau (XPAB); and the Liaohe Petroleum Exploration Bureau (LPEB). The visit also partially fulfilled AOSTRA's objective of assisting Alberta's petroleum service and equipment industries in developing business opportunities in China.

While in China, a series of discussions and negotiations took place in order to develop a cooperative research program. Six projects within the program were finalized and an agreement between AOSTRA and RIPED was signed on June 16, 1986 in Edmonton.

### *10.2 AOSTRA/UNITAR-UNDP Relationship*

AOSTRA continues to actively support the UNITAR/UNDP Information Centre for Heavy Oil and Tar Sands. During 1986, AOSTRA signed an agreement with the centre to co-sponsor the 4th International Conference on Heavy Crude and Tar Sands to be held in Edmonton, Alberta on August 7-12, 1988. In cooperation with many Alberta Government departments and private industry, AOSTRA has commenced organizing and planning activities for this conference.

## 11 Training Programs

AOSTRA continued its program of providing experience for up to 21 university summer students, who are mainly employed on AOSTRA-sponsored research projects conducted by university researchers. In addition, up to six co-op students are employed on a year-round basis for individual periods of four to eight months.

## 12 Industrial Post-Doctoral Fellowship Program

In 1983 AOSTRA initiated its industrial Post-Doctoral Fellowship Program which was designed to assist the transition of post-doctoral researchers from an academic to an industrial environment. During the two-year term of the award, valued at $22,500 per year, the AOSTRA Industrial Fellow conducts a research project in the laboratory of the sponsoring company which provides the space, equipment, and support personnel required for the proper conduct of the research.

Dr. Hans Vaziri, the current holder of the award, is studying the response of oil sands masses, subject to boundary conditions that may be imposed during the oil recovery process. The work is underway at the laboratory of Golder Associates Consulting Geotechnical and Mining Engineers in Calgary.

## 13 AOSTRA Technology Transfer

Technology developed from AOSTRA-funded projects and programs is available to those wishing to acquire access to this knowledge subject to reasonable business terms and conditions.

In recognition of the importance of technology transfer and the eventual commercialization of AOSTRA-owned technology, an office of technology sales was established in May 1987. Any person wishing to purchase or gather information on available technology should contact the Manager, Technology Sales.

Technology from AOSTRA is categorized as follows:

### *13.1 Completed Projects*

All AOSTRA projects which have been completed are indexed and catalogued. In many cases, the technical information developed in these projects has been divided into component packages for use by an eventual purchaser. The price of AOSTRA technology is not based on the costs for development, but is dependent upon its usefulness and is subject to negotiation between the purchaser, AOSTRA and its partners. If no agreement can be reached, the matter can be referred to arbitration to establish a fair market value.

### *13.2 Active Projects*

Technology may also be accessed on an ongoing basis from a currently operating project by joining the project as an active participant. Participants with more than 12.5% equity get voting rights and a world-wide license fee-free right to use the technology. An alternative approach is through the consultive participant route in which the participant pays less than 12.5% of the cost, does not get voting privileges and acquires technology use rights.

#### *13.2.1 University Research Projects*

Over the past year, a total of eleven companies and research institutes have been accessing the results from the university projects. These industry participants jointly pay more than 24% of the cost of the university activity. Under this access program, member companies earn non-exclusive use rights and have the privilege of visiting the various laboratories and interacting with the researchers.

#### *13.2.2 Joint AOSTRA/ARC Laboratory Program*

There are currently four companies accessing this $3.5 million program which is funded jointly by AOSTRA and the Alberta Research Council. This program which is based on an annual access fee of $60,000 provides for the non-exclusive use of the technology and for meaningful input into the direction and content of the research work.

Companies are encouraged to become actively involved in the research program and to talk directly to the scientists and engineers at ARC.

#### *13.2.3 The Data Base Management System*

As outlined in Section 1.12, the ADBS and ADBS II provide full data storage, access, and reporting capabilities for in situ pilot projects. Seven companies operating eight projects are currently using the system. Licensing arrangements are made between AOSTRA and individual companies with system charges being directly related to the volume of data and amount of use. AOSTRA will arrange for a "live demonstration" of system capabilities for interested companies.

## 14 Publications, Conferences, and Workshops

AOSTRA is continuing efforts in publishing technical reports as part of the AOSTRA Technical Publication Series. All publications in this series are available to the public and more information can be obtained from the AOSTRA Library and Information Service. The AOSTRA Journal of Research, which is published on a quarterly basis, concentrates on articles related to oil sands, heavy oils, oil source rocks, and tertiary recovery of conventional petroleum. (See Information section of this report for editorial and subscription information.)

In continuing with its policy of making new technology available to the public, AOSTRA organized the following conferences and workshops:

- The regular meeting for participants in AOSTRA's University Access Program was held in Banff in October 1986. This annual event allows university professors who are conducting AOSTRA-supported research the opportunity to discuss their work with the industrial participants.
- The annual spring conference was held in Calgary in June 1986. This year the technical program featured three sessions: an update of AOSTRA programs; current petroleum-related research being carried out in the People's Republic of China; and the number of companies attempting to make profitable ventures from pilot projects in Alberta.
- In February 1986, a small group of upgrading experts from Canada and the USA met in Edmonton for a two-day workshop to discuss common problems and possible solutions.
- Work began during 1986 in the planning of a five-day conference to be held in Edmonton in 1988. This conference will be co-sponsored by AOSTRA and the UNITAR/UNDP Information Centre for Heavy Crude and Tar Sands, a branch of the United Nations.

## 15 Economic Analyses

Economic evaluations have an important role in guiding the direction of research and in the development of new and improved technology. AOSTRA utilizes economic evaluations of proposed and active research projects to determine their potential economic viability. Results from completed projects are evaluated to establish the potential value of technology that is available for sale and licensing. Economic studies provided by applicants, and by project participants, as well as studies developed by individuals responsible for the administration and monitoring of projects are utilized. During the past year, economic studies have included: a reassessment of the economics of a number of processes previously evaluated for upgrading of bitumen and heavy oils; evaluation of the potential economics of the HSC/ROSE® process; and evaluation of active and proposed in situ recovery projects using a computer model designed for that specific application. In a joint program with other Alberta government agencies, AOSTRA has participated in macro energy modeling studies using models developed by the Alberta Research Council and the Alberta Department of Energy. The studies provide guidance in understanding the potential development of Alberta's energy resources and the potential role of oil sand and heavy oil developments.

# 16 AOSTRA Library and Information Services

A major effort undertaken by the AOSTRA Library and Information Services (ALIS) this year was to bring together all AOSTRA confidential reports and to create databases and filing systems for them. This includes information from: the AOSTRA/University research program; the AOSTRA/ industry field pilots; and the AOSTRA/industry mining, extraction and upgrading reports. Other ALIS databases — AOSTRA-ARC Access Program, Alberta Oil Sands Index (AOSI), and the Heavy Oil-Enhanced Recovery Index (HERI) — have been maintained and updated as in the past. A new feature this year is the availability of AOSI and HERI on microfiche in addition to the printed and on-line formats. ALIS continues to handle distribution of the Tar Paper, the AOSTRA Journal of Research, as well as publications from the AOSTRA Technical Publications Series. (See Information section for address.)

# 17 Patents

## *17.1 AOSTRA Patents*

The following patents and patent applications are assigned to AOSTRA:

**a) Canadian Patents**

| Patent No. | Date Issued | Patent Title |
|---|---|---|
| 1,120,418 | Mar 23/82 | Process and Apparatus for Thermally Procesding Heavy Hydrocarbon-Containing Liquids (W. Taciuk) |
| 1,121,749 | Apr 3/82 | Apparatus and Process for Recovery of Hydrocarbons from Inorganic Host Materials (W. Taciuk) |
| 1,102,234 | Jun 2/81 | Gaseous and Solvent Additives for Steam Injection for Thermal Recovery of Bitumen from Tar Sands (D.A. Redford and M.R. Hanna) |
| 1,122,015 | Apr 20/82 | Process for Microbiologically Leaching Coke (T.R. Jack et al) |
| 1,129,801 | Aug 17/82 | Alkali Recycle Process for Recovery of Heavy Oils and Bitumens (M.A. Kessick) |
| 1,134,174 | Oct 26/82 | Two-Phase Wet Steam Flowmeter (D.S. Scott and E. Rhodes) |
| 1,158,458 | Dec 13/83 | Variable Drive for Pump Jack (D.L. Buckler) |
| 1,120,367 | Jun 7/84 | Catalytic Sulfur Removal from Hydrocarbons (P.M. Boorman et al) |
| 1,170,444 | Jul 10/84 | Use of Hydrogen-Free Carbon Monoxide with Steam in Recovery of Heavy Oil at Low Temperatures (J.B. Hyne and J.D. Tyrer) |
| 1,171,382 | Jul 24/84 | Electrophoretic Process for Separating Aqueous Mineral Suspensions (R.A. Ritter) |

| Patent No. | Date Issued | Patent Title |
|---|---|---|
| 1,844,022 | Mar 19/85 | Use of Surfactants to Improve Oil Recovery During Steam Flooding (E.E. Isaacs and D.R. Prowse) |
| 1,189,444 | Jun 25/85 | Additive for Inclusion in a Heavy Oil Reservoir Undergoing Steam Injection (J.B. Hyne and P.D. Clarke) |
| 1,210,358 | Aug 26/86 | Process for Upgrading a Heavy Viscous Hydrocarbon (I.H. Lutz) (Acres Davy McKee D.M. International, Inc., Houston, Texas) |

**b) Canadian Patent Applications**

| Application No. | Date Filed | Patent Application Title |
|---|---|---|
| 379,072 | Feb 22/83 | Improved Process for Recovery of Residual Bitumen from Tailings from Oil Sand Extraction Plants (E.L. Tollefson and E.S. Hall) |
| 458,921 | Jul 13/84 | Two Phase Flowmeter (D.S. Scott and E. Rhodes) |
| 491,238 | Sep 20/85 | Apparatus for Continuously Separating Particulate Solids from Liquid Suspensions (R.A. Ritter) |
| 491,237 | Sep 20/85 | Commutator (R.A. Ritter) |
| 491,838 | Sep 30/85 | Method for Controlling Water Coning in Oil Wells (R.W. Luhning and K.R. Ronaghan) |
| 487,714 | Jul 29/85 | Microwave Induced Catalytic Conversion of Methane to Ethylene and Hydrogen (J. Wan) |
| 517,837 | Sep 9/86 | Pressure-Up/Blowdown Combustion - A Channelled Reservoir Recovery Process (R.J. Hallam and J.K. Donnelly) |

**c) U.S. Patents**

| Patent No. | Date Issued | Patent Title |
|---|---|---|
| 4,180,455 | Dec 25/79 | Process for Thermal Cracking a Heavy Hydrocarbon (W. Taciuk) |
| 4,280,879 | Jul 28/81 | Apparatus and Process for Recovery of Hydrocarbons from Inorganic Host Materials (W. Taciuk) |
| 4,306,961 | Dec 22/81 | Process for Recovery of Hydrocarbons from Inorganic Host Materials (W. Taciuk - Tar-sand Version) |
| 4,285,773 | Aug 25/81 | Apparatus and Process for Recovery of Hydrocarbons from Inorganic Host Materials (W. Taciuk - Lloydminster Version) |
| 4,312,234 | Jan 26/82 | Two-Phase Wet Steam Flow Meter (D.S. Scott and E. Rhodes) |
| 4,271,905 | Jun 9/81 | Gaseous and Solvent Additives for Steam Injection for Thermal Recovery of Bitumen from Tar Sands (D.A. Redford and M.R. Hanna) |

| Patent No. | Date Issued | Patent Title |
|---|---|---|
| 4,438,218 | Mar 20/84 | Catalytic Sulfur Removal from Hydrocarbons (P.M. Boorman et al) |
| 4,454,023 | Jul/Aug/84 | Process for Upgrading a Heavy Viscous Oil (Hydrocarbon) (I. Lutz) (Acres Davy McKee DM International, Inc., Houston) |
| 4,458,759 | Jul 10/84 | Use of Surfactants to Improve Oil Recovery During Steam Flooding (E.E. Isaacs and D.R. Prowse) |
| 4,487,264 | Dec 11/84 | Use of Hydrogen-Free Carbon Monoxide with Steam in Recovery of Heavy Oil at Low Temperatures (J.B. Hyne and J.D. Tyrer) |
| 4,501,648 | Feb 26/85 | Electrophoretic Process for Separating Aqueous Mineral Suspensions (R.A. Ritter) |
| 4,506,733 | Mar 26/85 | Additive for Inclusion in a Heavy Oil Reservoir Undergoing Steam Injection (J.B. Hyne and P.D. Clarke) |
| 4,574,643 | Mar 11/86 | Two-Phase Wet Steam Flowmeter (D.S. Scott and E. Rhodes) |
| 4,574,038 | Mar 4/86 | Microwave Induced Catalytic Conversion of Methane to Ethylene and Hydrogen (J. Wan) |

**d) U.S. Patent Applications**

| Application No. | Date Filed | Patent Application Title |
|---|---|---|
| 06/294,523 | Aug 20/81 | Variable Speed Pump Jack (D.L. Buckler) |
| 784,933 | Oct 7/85 | Method for Controlling Water Coning in Oil Wells (R.W. Luhning and K.R. Ronaghan) |
| 834,177 | Feb 2/86 | Method for Obtaining Horizontal Fractures in an Oil Reservoir (T. Harding et al) |
| 908,306 | Sep 17/86 | Pressure-up/Blowdown Combustion - A Channelled Reservoir Recovery Process (R.J. Hallam and J.K. Donnelly) |

**e) Venezuela Patents**

| Patent No. | Date Issued | Patent Title |
|---|---|---|
| 1993/79 | Aug 7/86 | Process and Apparatus for Thermally Processing Heavy Hydrocarbon-containing Liquids (W. Taciuk) |

**f) Venezuela Patent Applications**

| Application No. | Date Filed | Patent Application Title |
|---|---|---|
| 0067 | Jan 21/81 | Gaseous and Solvent Additives for Steam Injection for Thermal Recovery of Bitumen from Tar Sands (D.A. Redford and M.R. Hanna) |
| 264 | Feb 25/80 | Apparatus and Process for Recovery of Hydrocarbons from Inorganic Host Materials (W. Taciuk) |

| Patent No. | Date Issued | Patent Title |
|---|---|---|
| 991/80 | Jun 10/80 | Process for Microbiologically Leaching Coke (J. Zajic/Sullivan) |
| 785/81 | May 9/81 | Two-Phase Wet Steam Flow Meter (D.S. Scott and E. Rhodes) |
| 108/82 | Jan 22/82 | Wet Combustion Process (D.W. Bennion, R.G. Moore, and K. Donnelly) |
| 1299/82 | Jul 21/82 | Use of Hydrogen-Free Carbon Monoxide with Steam in Recovery of Heavy Oil at Low Temperatures (J.B. Hyne/J.D. Tyrer) |
| 1803/83 | Nov 11/83 | Additive for inclusion in a Heavy Oil Reservoir Undergoing Steam Injection (J.B. Hyne and P.D. Clarke) |

**g) Mexico Patent Applications**

| Application No. | Date Filed | Patent Application Title |
|---|---|---|
| 179,758 | Oct 24/79 | Process and Apparatus for Thermally Processing Heavy Hydrocarbon-Containing Liquids (W. Taciuk) |
| 200,744 | Mar 22/84 | Process for Upgrading a Heavy Viscous Oil (Hydrocarbon) (I. Lutz) (Acres Davy McKee DM) |

**h) European (EEC) Patents**

| Patent No. | Date Filed | Patent Title |
|---|---|---|
| 0-028-666 | Apr 6/83 | Process and Apparatus for Thermally Processing Heavy Hydrocarbon-Containing Liquids W. Taciuk) (Belgium, France, Italy, Netherlands, and U.K.) |
| 79,302542.0 | | (Sweden) |
| 29-65-154.5 | | (Germany) |
| 81.304752.9 | Oct 13/81 | Two-Phase Flowmeter (D.S. Scott and E. Rhodes) |
| 84.301888.8 | Mar 20/84 | Process for Upgrading a Heavy Viscous Oil (Hydrocarbon) (I. Lutz) (Acres Davy McKee DM International, Inc., Houston) |

**i) Argentina Patent Applications**

| Application No. | Date Filed | Patent Application Title |
|---|---|---|
| 279,427 | Dec 21/79 | Process and Apparatus for Thermally Processing Heavy Hydrocarbon-Containing Liquids (W. Taciuk) |

**j) Romania Patent Applications**

| Application No. | Date Filed | Patent Application Title |
|---|---|---|
| 99095 | Oct 30/79 | Process and Apparatus for Thermally Processing Heavy Hydrocarbon-Containing Liquids (W. Taciuk) |

**k) Turkey Patent Applications**

| Application No. | Date Filed | Patent Application Title |
|---|---|---|
| 144261 | Dec 21/79 | Process and Apparatus for Thermally Processing Heavy Hydrocarbon-Containing Liquids (W. Taciuk) |

**l) Japan Patent Applications**

| Application No. | Date Filed | Patent Application Title |
|---|---|---|
| 138227/79 | Oct 25/79 | Process and Apparatus for Thermally Processing Heavy Hydrocarbon-Containing Liquids (W. Taciuk) |

***17.2 Prior Company Patents*** (for which AOSTRA has acquired certain licensing rights)

**a) Canadian Patents**

| | Patent No. | Date Issued | Date Filed | Related U.S. Patent No. | Patent Titles |
|---|---|---|---|---|---|
| 1. | 839042 | 04-14-70 | 03-18-66 | — | Method of Producing Hydro carbons from a Subsurface Formation by Thermal Treatment |
| 2. | 840789 | 05-05-70 | 01-17-66 | — | Method of Producing Hydrocarbons from an Underground Formation |
| 3. | 856023 | 11-17-70 | 02-23-68 | — | Consolidating Earth Formations |
| 4. | 858309 | 12-15-70 | 23-68 | — | Thermal Secondary Recovery |
| 5. | 890741 | 01-18-72 | 02-21-69 | — | Method of Recovering Hydrocarbons from an Underground Hydrocarbon-Containing Formation |
| 6. | 941735 | 02-12-74 | 06-01-71 | — | Oil Recovery Using Steam and Chemical Drive Fluids |
| 7. | 1125649 | 01-15-82 | 12-19-79 | 4234042 | Direct Combustion Stimulation of a Producing Well |
| 8. | 1118341 | 02-16-82 | 09-14-79 | 4272487 | Indirect Thermal Stimulation of Producing Wells |

**b) U.S. Patents**

| | Patent No. | Date Issued | Date Filed | Related Canadian Patent No. | Patent Titles |
|---|---|---|---|---|---|
| 1. | 3504745 | 04-07-70 | 05-08-68 | 853995 | Use of Foams to Prevent Vertical Flow in Tar Sands During In Situ Combustion |
| 2. | 3547195 | 12-15-70 | 06-19-69 | 881914 | Pyrolitic Plugging of Oil Bearing Formations by Underground Combustion |
| 3. | 3729337 | 04-24-73 | 04-20-70 | — | Production of Petroleum from Unconsolidated Formations |
| 4. | 3964547 | 06-22-76 | 10-29-74 | 972679 | Use of Tar as a Diverter in Steaming Operations |
| 5. | 4147213 | 04-03-79 | — | — | Combustion Air Injection Well |
| 6. | 4234042 | 11-18-80 | 06-11-79 | 1125649 | Direct Combustion Stimulation of a Producing Well |
| 7. | 4272487 | — | 01-01-79 | 1118341 | Indirect Thermal Stimulation of Producing Wells |

# Tables

# Table 1

**Oil Sands Technology and Research Fund**
**Summary of Funds Committed and Disbursed**
**As at March 31, 1987**

| Project | Funds Committed | Prior Years' Disbursements | Disbursements April 1/86 to March 31/87 | Balance |
|---|---|---|---|---|
| ***Institutional Research*** | | | | |
| Alberta Research Council | | | | |
| — Information Centre | $ 4,500,600 | $ 3,692,161 | $ 591,096 | $ 217,343 |
| — Oil Sands Research Centre | 26,193,027 | 23,275,906 | 1,972,980 | 944,141 |
| — Sample Bank | 1,551,143 | 1,253,128 | 155,588 | 142,427 |
| — Geological Program | 3,781,009 | 3,117,325 | 517,955 | 145,729 |
| — Hydrocarbon Program | 2,250,000 | 1,328,508 | 773,341 | 148,151 |
| — Strategic Research Program | 1,500,000 | — | 1,249,256 | 250,744 |
| — Macro Energy Modelling | 100,000 | 17,000 | 17,000 | 66,000 |
| Inventors Assistance Grant | 629,040 | 427,899 | 82,562 | 118,579 |
| University Contracts | 25,744,079 | 20,112,072 | 2,952,754 | 2,679,253 |
| Professorships | 4,001,109 | 3,418,242 | 411,389 | 171,478 |
| New Graduate Assistance Program | 200,000 | — | 7,847 | 192,153 |
| Post Doctoral Fellowships | 100,000 | 46,040 | — | 53,960 |
| Scholarships and Fellowships | 3,480,000 | 2,071,011 | 336,883 | 1,072,106 |
| Hatch and Associates | 383,950 | 373,190 | — | 10,760 |
| British Columbia Cancer Foundation | 125,000 | 123,037 | — | 1,963 |
| British Columbia Research Council | 67,600 | 67,600 | — | — |
| ARC Access Program | 25,000 | 8,234 | 1,214 | 15,552 |
| University Access Program | 175,000 | 165,566 | 8,697 | 737 |
| Program Planning and Evaluation | 500,000 | 272,377 | 54,243 | 173,380 |
| Technical Review | 1,084,000 | 969,613 | 35,075 | 79,312 |
| Petroleum Recovery Institute | 3,189,252 | 2,187,568 | 1,000,000 | 1,684 |
| Centre for Frontier Engineering Research | 25,000 | 25,000 | — | — |
| Syncrude Canada Ltd. | 797,400 | 764,121 | 32,909 | 370 |
| Computer Modelling Group | 220,000 | — | 220,000 | — |
| Unitar Conference | 329,000 | — | 65,605 | 263,395 |
| Completed Projects | 6,098 | 6,098 | — | — |
| | $ 80,957,307 | $ 63,721,696 | $ 10,486,394 | $ 6,749,217 |
| ***Mining and Extraction*** | | | | |
| Retorting | | | | |
| — Umatac | $ 15,667,500 | $ 14,187,711 | $ 1,182,251 | $ 297,538 |
| — Lurgi | 721,820 | 545,019 | — | 176,801 |
| Tailings Treatment | | | | |
| — Syncrude | 1,800,000 | 1,000,000 | 800,000 | — |
| Oil Sands Demonstration Centre | 425,000 | 264,032 | 59,745 | 101,223 |
| Suncor/Kruyer Project | 915,000 | 877,540 | 940 | 36,520 |
| Nova/Husky/Canstar | 176,700 | 22,420 | 121,129 | 33,151 |
| Dravo Engineers Inc. | 150,000 | 147,182 | — | 2,818 |
| Seaton Project | 170,000 | — | — | 170,000 |
| Esso Resources Oslo Project | 30,000 | — | 30,000 | — |
| Terra Energy Sesa Project | 500,000 | — | — | 500,000 |
| Shell Canada/Solv-Ex | 3,000,000 | — | 2,843,900 | 156,100 |
| Completed Projects | 3,382,129 | 3,382,129 | — | — |
| | $ 26,938,149 | $ 20,426,033 | $ 5,037,965 | $ 1,474,151 |

# Table 1

**Oil Sands Technology and Research Fund**
**Summary of Funds Committed and Disbursed**
**As at March 31, 1987**
**(continued)**

| Project | Funds Committed | Prior Years' Disbursements | Disbursements April 1/86 to March 31/87 | Balance |
|---|---|---|---|---|
| ***In Situ Oil Sands*** | | | | |
| Peace River | | | | |
| — Shell | $ 76,039,351 | $ 62,329,900 | $ 12,299,010 | $ 1,410,441 |
| Athabasca | | | | |
| — Amoco | 24,947,108 | 23,814,243 | 5,432 | 1,127,433 |
| — Amoco/Petro-Canada | 17,108,250 | 7,940,056 | 3,953,698 | 5,214,496 |
| — Canterra Energy Ltd. | 46,861,000 | 24,472,743 | 3,299,311 | 19,088,946 |
| — Texaco Canada | 1,515,000 | 1,466,867 | — | 48,133 |
| Cold Lake | | | | |
| — B.P. | 25,596,000 | 21,261,609 | 2,589,985 | 1,744,406 |
| — B.P./Petro-Canada | 1,499,250 | 1,114,800 | 35,349 | 349,101 |
| — Bow Valley Industries | 13,112,000 | 8,412,321 | 2,833,056 | 1,866,623 |
| — Suncor Ft. Kent | 400,000 | 81,096 | 37,883 | 281,021 |
| — Technica | 7,000 | 5,645 | — | 1,355 |
| Francis Hankin | 457,009 | 432,100 | — | 24,909 |
| Mineralogical Study | 6,250 | 5,882 | (5) | 373 |
| Water Treatment Study | 408,480 | 304,882 | — | 103,598 |
| Simtech Consulting | 35,000 | 18,890 | 9,442 | 6,668 |
| Waterloo Centre Water Treatment Project | 375,000 | — | — | 375,000 |
| Shell Water Treatment Project | 700,000 | — | — | 700,000 |
| Completed Projects | 7,384,629 | 7,365,579 | 19,050 | — |
| | $216,451,327 | $159,026,613 | $ 25,082,211 | $ 32,342,503 |
| ***Underground Access*** | | | | |
| Athabasca | | | | |
| — U.T.F. Project | $ 61,281,947 | $ 39,810,245 | $ 11,248,413 | $ 10,223,289 |
| — Completed Projects | 5,108,264 | 5,108,264 | — | — |
| | $ 66,390,211 | $ 44,918,509 | $ 11,248,413 | $ 10,223,289 |
| ***Carbonate Trend*** | | | | |
| Buffalo Creek | | | | |
| — Union Oil | $ 31,185,000 | $ 28,031,275 | $ 2,860,676 | $ 293,049 |
| Chevron | 374,000 | 272,572 | 137 | 101,291 |
| Total Petroleum | 40,000 | 35,372 | — | 4,628 |
| Completed Projects | — | — | — | — |
| | $ 31,599,000 | $ 28,339,219 | $ 2,860,813 | $ 398,968 |
| ***Heavy Oil*** | | | | |
| Petro-Canada | $ 14,308,046 | $ 13,608,369 | $ 314,066 | $ 385,611 |
| Alberta Energy Company | 6,684,500 | 5,671,867 | 585,204 | 427,429 |
| Norcen International Ltd. | 8,250,000 | 116,079 | 6,914,181 | 1,219,740 |
| PanCanadian Petroleum | 1,500,000 | 549,385 | 145,688 | 804,927 |
| Completed Projects | 239,674 | 239,674 | — | — |
| | $ 30,982,220 | $ 20,185,374 | $ 7,959,139 | $ 2,837,707 |

# Table 1

**Oil Sands Technology and Research Fund**
**Summary of Funds Committed and Disbursed**
**As at March 31, 1987**
**(continued)**

| Project | Funds Committed | Prior Years' Disbursements | Disbursements April 1/86 to March 31/87 | Balance |
|---|---|---|---|---|
| ***Enhanced Recovery Conventional Oil*** | | | | |
| Vikor Resources Ltd. | $ 4,000,000 | $ 2,835,378 | $ 484,889 | $ 679,733 |
| Hudson's Bay Oil & Gas | 2,462,500 | 1,437,929 | 129,714 | 894,857 |
| Robinson Slim Tube Test | 169,240 | — | 7,559 | 161,681 |
| Canterra's Solids Disposition Project | 99,250 | — | 81,213 | 18,037 |
| Saskatchewan Research Council | 15,000 | — | — | 15,000 |
| Westgrowth Petroleums Ltd. | 600,000 | — | 600,000 | — |
| Completed Projects | 1,033,391 | 1,030,516 | 2,875 | — |
| | $ 8,379,381 | $ 5,303,823 | $ 1,306,250 | $ 1,769,308 |
| ***Bitumen Upgrading*** | | | | |
| Residue Utilization Project | $ 1,398,232 | $ 811,150 | $ 210,187 | $ 376,895 |
| Heavy Oil Upgrading Demo Centre | 85,000 | 78,074 | 24,201 | (17,275) |
| Bitumen/Water Transportation Study | 80,000 | 12,008 | 118 | 67,874 |
| California Synfuels | 414,760 | 269,994 | (20,619) | 165,385 |
| Gulf Oil - Donor Process | 12,727,000 | 4,937,225 | 7,797,560 | (7,785) |
| Murphy Oil | 50,000 | 44,641 | 4,338 | 1,021 |
| Acres Davy McKee | 80,000 | 60,000 | — | 20,000 |
| Toyo Engineering | 275,711 | 188,848 | 86,863 | — |
| Veba Oil | 3,265,000 | — | 368,131 | 2,896,869 |
| H.R.I. | 1,656,200 | — | 1,440,803 | 215,397 |
| Completed Projects | 4,424,333 | 4,424,333 | — | — |
| | $ 24,456,236 | $ 10,826,273 | $ 9,911,582 | $ 3,718,381 |
| ***Technology Handling*** | | | | |
| Data Base Administration | $ 3,723,515 | $ 2,957,450 | $ 498,061 | $ 268,004 |
| AOSTRA Journal | 359,773 | 311,905 | 45,311 | 2,557 |
| Patent Costs | 500,000 | 484,270 | 15,730 | — |
| AOSTRA Technical Handbook | 100,000 | 219 | — | 99,781 |
| Completed Projects | 91,865 | 91,865 | — | — |
| | $ 4,775,153 | $ 3,845,709 | $ 559,102 | $ 370,342 |
| ***Training Activities*** | $ 1,865,000 | $ 1,539,890 | $ 219,758 | $ 105,352 |
| ***International Activities*** | $ 1,780,800 | $ 1,533,395 | $ 71,687 | $ 175,718 |
| ***Authority Costs*** | $ 2,000,000 | $ 1,268,080 | $ 448,223 | $ 283,697 |
| ***Totals*** | $496,574,784 | $360,934,614 | $ 75,191,537 | $ 60,448,633 |

# Table 2

**Oil Sands Technology and Research Fund**
**Statement of Revenue**
**Expenditure and Fund Balance**

**Twelve-Year Summary**
**For the years ended March 31**

| | 1987 | 1986 | 1985 |
|---|---|---|---|
| ***Revenue*** | | | |
| Alberta Heritage Savings Trust Fund | $ 31,400,000 | $ 50,000,000 | $ 50,000,000 |
| Alberta General Revenue Fund | 34,700,000 | — | — |
| Technology Sales | 1,227,125 | 2,156,404 | 2,056,808 |
| | $ 67,327,125 | $ 52,156,404 | $ 52,056,808 |
| ***Expenditures*** | | | |
| ***Institutional Research*** | | | |
| Alberta Research Council | | | |
| — Information Centre | $ 591,097 | $ 499,620 | $ 551,962 |
| — Oil Sands Research Centre | 1,972,980 | 3,015,466 | 2,915,270 |
| — Sample Bank | 155,588 | 157,118 | 93,205 |
| — Geological Program | 517,955 | 309,345 | 753,092 |
| — Hydrocarbon Program | 773,341 | 797,636 | 530,872 |
| — Strategic Research Program | 1,249,256 | — | — |
| — Macro Energy Modelling | 17,000 | 17,000 | — |
| Inventors Assistance Grant | 82,562 | 117,119 | 180,780 |
| University Contracts | 2,952,754 | 2,869,781 | 2,994,843 |
| Professorships | 411,389 | 493,856 | 560,622 |
| New Graduate Assistance Program | 7,847 | — | — |
| Post Doctoral Fellowships | — | 22,500 | 22,500 |
| Scholarships and Fellowships | 336,883 | 411,063 | 388,920 |
| Hatch and Associates | — | 4,918 | 122,014 |
| British Columbia Cancer Foundation | — | 10,932 | 5,466 |
| British Columbia Research Council | — | 18,100 | 49,500 |
| ARC Access Program | 1,213 | 3,476 | 514 |
| University Access Program | 8,697 | 17,975 | 13,861 |
| Program Planning and Evaluation | 54,243 | 66,216 | 85,675 |
| Technical Review | 35,075 | 98,217 | 798,958 |
| Petroleum Recovery Institute | 1,000,000 | 1,125,562 | 547,690 |
| Centre for Frontier Engineering Research | — | 25,000 | — |
| Syncrude Canada Ltd. | 32,909 | 209,085 | (26,694) |
| Computer Modelling Group | 220,000 | — | — |
| Unitar Conference | 65,605 | — | — |
| Completed Projects | — | — | — |
| | $ 10,486,394 | $ 10,289,985 | $ 10,589,050 |
| ***Mining and Extraction*** | | | |
| Retorting | | | |
| — Umatac | $ 1,182,251 | $ 2,460,548 | $ 2,948,229 |
| — Lurgi | — | — | — |
| Tailings Treatment | | | |
| — Syncrude | 800,000 | 1,000,000 | — |
| Oil Sands Demonstration Centre | 59,745 | 99 | 36,935 |
| Suncor/Kruyer Project | 940 | 438,861 | 378,679 |
| Nova/Husky/Canstar | 121,129 | 22,420 | — |
| Dravo Engineers Inc. | — | 147,183 | — |
| Esso Resources Oslo Project | 30,000 | — | — |
| Shell Canada/Solv-Ex | 2,843,900 | — | — |
| Completed Projects | — | 12,265 | 185,171 |
| | $ 5,037,965 | $ 4,081,376 | $ 3,549,014 |

| 1984 | 1983 | 1982 and Prior | Total |
|---|---|---|---|
| $ 54,500,000 | $ 39,500,000 | $157,449,032 | $382,849,032 |
| — | — | — | 34,700,000 |
| 1,988,107 | 2,876,477 | 6,545,416 | 16,850,337 |
| $ 56,488,107 | $ 42,376,477 | $163,994,448 | $434,399,369 |

| | | | |
|---|---|---|---|
| $ 495,183 | $ 438,174 | $ 1,707,222 | $ 4,283,258 |
| 3,236,077 | 2,877,172 | 11,231,921 | 25,248,886 |
| 134,761 | 261,881 | 606,163 | 1,408,716 |
| 642,157 | 521,195 | 891,535 | 3,635,279 |
| — | — | — | 2,101,849 |
| — | — | — | 1,249,256 |
| — | — | — | 34,000 |
| 130,000 | — | — | 510,461 |
| 3,152,248 | 3,478,549 | 7,616,652 | 23,064,827 |
| 461,515 | 546,121 | 1,356,127 | 3,829,630 |
| — | — | — | 7,847 |
| 1,040 | — | — | 46,040 |
| 383,807 | 184,823 | 702,398 | 2,407,894 |
| 246,258 | — | — | 373,190 |
| 63,514 | 43,126 | — | 123,038 |
| — | — | — | 67,600 |
| 4,244 | — | — | 9,447 |
| 35,918 | 26,771 | 71,042 | 174,264 |
| 120,486 | — | — | 326,620 |
| 72,438 | — | — | 1,004,688 |
| 514,315 | — | — | 3,187,567 |
| — | — | — | 25,000 |
| 581,730 | — | — | 797,030 |
| — | — | — | 220,000 |
| — | — | — | 65,605 |
| — | — | 6,098 | 6,098 |
| $ 10,275,691 | $ 8,377,812 | $ 24,189,158 | $ 74,208,090 |

| | | | |
|---|---|---|---|
| $ 2,800,255 | $ 1,532,063 | $ 4,446,615 | $ 15,369,961 |
| 38,579 | (114,724) | 621,165 | 545,020 |
| — | — | — | 1,800,000 |
| 218,782 | (33,106) | 41,322 | 323,777 |
| 60,000 | — | — | 878,480 |
| — | — | — | 143,549 |
| — | — | — | 147,183 |
| — | — | — | 30,000 |
| — | — | — | 2,843,900 |
| 403,769 | 967,507 | 1,813,416 | 3,382,128 |
| $ 3,521,385 | $ 2,351,740 | $ 6,922,518 | $ 25,463,998 |

# Table 2

**Oil Sands Technology and Research Fund**
**Statement of Revenue**
**Expenditure and Fund Balance**

**Twelve-Year Summary**
**For the years ended March 31**
**(continued)**

| | 1987 | 1986 | 1985 |
|---|---|---|---|
| ***In Situ Oil Sands*** | | | |
| Peace River | | | |
| — Shell | $ 12,299,010 | $ (1,572,687) | $ 806,095 |
| Athabasca | | | |
| — Amoco | 5,432 | (47,191) | (726,689) |
| — Amoco/Petro-Canada | 3,953,698 | 2,013,365 | 5,854,969 |
| — Canterra Energy Ltd. | 3,299,311 | 3,063,138 | 15,199,377 |
| — Texaco Canada | — | 84,350 | 1,340,947 |
| Cold Lake | | | |
| — B.P. | 2,589,985 | 2,692,069 | 3,474,113 |
| — B.P./Petro-Canada | 35,349 | 281,730 | 192,092 |
| — Bow Valley Industries | 2,833,056 | 2,397,730 | 5,663,041 |
| — Suncor Ft. Kent | 37,883 | (9,284) | 75,739 |
| — Technica | — | — | 5,645 |
| Francis Hankin | — | — | 26,500 |
| Mineralogical Study | (5) | 4,881 | — |
| Water Treatment Study | — | 18,987 | 153,273 |
| Simtech Consulting | 9,442 | 18,890 | — |
| Completed Projects | 19,050 | — | 39,007 |
| | $ 25,082,211 | $ 8,945,978 | $ 32,104,109 |
| ***Underground Access*** | | | |
| Athabasca | | | |
| — U.T.F. Project | $ 11,248,413 | $ 15,691,395 | $ 19,452,415 |
| — Completed Projects | — | — | — |
| | $ 11,248,413 | $ 15,691,395 | $ 19,452,415 |
| ***Carbonate Trend*** | | | |
| Buffalo Creek | | | |
| — Union Oil | $ 2,860,676 | $ 2,234,802 | $ 4,380,864 |
| Chevron | 137 | 272,067 | 506 |
| Total Petroleum | — | 35,372 | — |
| Completed Projects | — | — | — |
| | $ 2,860,813 | $ 2,542,241 | $ 4,381,370 |
| ***Heavy Oil*** | | | |
| Petro-Canada | $ 314,067 | $ 316,747 | $ 1,541,199 |
| Alberta Energy Company | 585,204 | 422,242 | 349,412 |
| Norcen International Ltd. | 6,914,180 | 17,664 | 9,613 |
| PanCanadian Petroleum | 145,688 | 99,194 | 334,175 |
| Completed Projects | — | — | 56,470 |
| | $ 7,959,139 | $ 855,847 | $ 2,290,869 |

| 1984 | 1983 | 1982 and Prior | Total |
|---|---|---|---|
| $ 3,037,950 | $ 3,416,430 | $ 56,642,112 | $ 74,628,910 |
| (138,706) | 234,416 | 24,492,413 | 23,819,675 |
| 71,721 | — | — | 11,893,753 |
| 20,228 | 6,[illegible]0,000 | — | 27,772,054 |
| 41,570 | — | — | 1,466,867 |
| 878,015 | 1,789,022 | 12,428,389 | 23,851,593 |
| 101 | 640,877 | — | 1,150,149 |
| 111,290 | 240,260 | — | 11,245,377 |
| 14,641 | — | — | 118,979 |
| — | — | — | 5,645 |
| 379,905 | 25,695 | — | 432,100 |
| 1,001 | — | — | 5,877 |
| 133,767 | (4,283) | 3,137 | 304,881 |
| — | — | — | 28,332 |
| 3,862,625 | 1,474,768 | 1,989,180 | 7,384,630 |
| $ 8,414,108 | $ 14,007,185 | $ 95,555,231 | $184,108,822 |
| $ 3,376,745 | $ 1,289,690 | $ — | $ 51,058,658 |
| 21,192 | (20,803) | 5,107,875 | 5,108,264 |
| $ 3,397,937 | $ 1,268,887 | $ 5,107,875 | $ 56,166,922 |
| $ 2,950,100 | $ 6,385,525 | $ 12,079,983 | $ 30,891,950 |
| — | — | — | 272,710 |
| — | — | — | 35,372 |
| — | — | — | — |
| $ 2,950,100 | $ 6,385,525 | $ 12,079,983 | $ 31,200,032 |
| $ 993,554 | $ 2,105,364 | $ 8,651,505 | $ 13,922,436 |
| 224,545 | 311,857 | 4,363,811 | 6,257,071 |
| 3,513 | 85,289 | — | 7,030,259 |
| 116,017 | — | — | 695,074 |
| 25,934 | 36,808 | 120,460 | 239,672 |
| $ 1,363,563 | $ 2,539,318 | $ 13,135,776 | $ 28,144,512 |

# Table 2

**Oil Sands Technology and Research Fund**
**Statement of Revenue**
**Expenditure and Fund Balance**

**Twelve-Year Summary**
**For the years ended March 31**
**(continued)**

| | 1987 | 1986 | 1985 |
|---|---|---|---|
| ***Enhanced Recovery Conventional Oil*** | | | |
| Vikor Resources Ltd. | $ 484,889 | $ (698,262) | $ (1,036,981) |
| Hudson's Bay Oil & Gas | 129,714 | 1,437,929 | — |
| Robinson Slim Tube Test | 7,559 | — | — |
| Canterra's Solids Disposition Project | 81,213 | — | — |
| Saskatchewan Research Council | — | — | — |
| Westgrowth Petroleums Ltd. | 600,000 | — | — |
| Completed Projects | 2,875 | 1,476 | (6,439) |
| | $ 1,306,250 | $ 741,143 | $ (1,043,420) |
| ***Bitumen Upgrading*** | | | |
| Residue Utilization Project | $ 210,187 | $ 255,100 | $ 521,675 |
| Heavy Oil Upgrading Demo Centre | 24,201 | 44,622 | 20,391 |
| Bitumen/Water Transportation Study | 118 | (3,744) | 15,751 |
| California Synfuels | (20,619) | — | 33,859 |
| Gulf Oil Donor Process | 7,797,560 | 4,110,225 | 437,000 |
| Murphy Oil | 4,338 | 16,593 | 28,049 |
| Acres Davy McKee | — | 40,000 | 20,000 |
| Toyo Engineering | 86,863 | 188,847 | — |
| Veba Oil | 368,131 | — | — |
| H.R.I. | 1,440,803 | — | — |
| Completed Projects | — | — | 36,944 |
| | $ 9,911,582 | $ 4,651,643 | $ 1,113,669 |
| ***Technology Handling*** | | | |
| Data Base Administration | $ 498,062 | $ 480,930 | $ 502,730 |
| AOSTRA Journal | 45,310 | 149,749 | 124,471 |
| Patent Costs | 15,730 | 62,851 | 68,142 |
| AOSTRA Technical Handbook | — | 219 | — |
| Completed Projects | — | — | — |
| | $ 559,102 | $ 693,749 | $ 695,343 |
| ***Training Activites*** | $ 219,758 | $ 270,129 | $ 243,757 |
| ***International Activities*** | $ 71,687 | $ 109,690 | $ 444,666 |
| ***Authority Costs*** | $ 448,223 | $ 471,612 | $ 37,726 |
| | $ 75,191,537 | $ 49,344,788 | $ 73,858,568 |
| Excess of Revenue over Expenditures | $ (7,864,412) | $ 2,811,616 | $ (21,801,760) |
| Fund Balance at Beginning of Period | $ 6,137,634 | $ 3,326,018 | $ 25,127,778 |
| Fund Balance at End of Period | $ (1,726,778) | $ 6,137,634 | $ 3,326,018 |

| 1984 | 1983 | 1982 and Prior | Total |
|---|---|---|---|
| $ 4,570,621 | $ — | $ — | $ 3,320,267 |
| — | — | — | 1,567,643 |
| — | — | — | 7,559 |
| — | — | — | 81,213 |
| — | — | — | — |
| — | — | — | 600,000 |
| 613,199 | 58,560 | 363,720 | 1,033,391 |
| $ 5,183,820 | $ 58,560 | $ 363,720 | $ 6,610,073 |
| | | | |
| $ 23,730 | $ 10,645 | $ — | $ 1,021,337 |
| 13,061 | — | — | 102,275 |
| — | — | — | 12,125 |
| 223,378 | — | 12,757 | 249,375 |
| 390,000 | — | — | 12,734,785 |
| — | — | — | 48,980 |
| — | — | — | 60,000 |
| — | — | — | 275,710 |
| — | — | — | 368,131 |
| — | — | — | 1,440,803 |
| 387,584 | 1,682,790 | 2,317,014 | 4,424,332 |
| $ 1,037,753 | $ 1,693,435 | $ 2,329,771 | $ 20,737,853 |
| | | | |
| $ 654,653 | $ 549,409 | $ 769,726 | $ 3,455,510 |
| 32,353 | 5,334 | — | 357,217 |
| 110,307 | 45,886 | 197,084 | 500,000 |
| — | — | — | 219 |
| — | — | 91,865 | 91,865 |
| $ 797,313 | $ 600,629 | $ 1,058,675 | $ 4,404,811 |
| | | | |
| $ 328,732 | $ 289,725 | $ 407,548 | $ 1,759,649 |
| $ 325,160 | $ 232,466 | $ 421,413 | $ 1,605,082 |
| $ 121,980 | $ — | $ 636,762 | $ 1,716,303 |
| $ 37,717,542 | $ 37,805,282 | $162,208,430 | $436,126,147 |
| $ 18,770,565 | $ 4,571,195 | $ 1,786,018 | $ (1,726,778) |
| $ 6,357,213 | $ 1,786,018 | $ — | $ — |
| $ 25,127,778 | $ 6,357,213 | $ 1,786,018 | $ (1,726,778) |

# Auditor's Report and Financial Statements

**Alberta Oil Sands**
**Technology and Research Authority**
**Oil Sands Technology and Research Fund**
**Financial Statements**
**March 31, 1987**


**Auditor's Report**

**Balance Sheet**

**Statement of Revenue, Expenditure and Fund Balance**

**Notes to the Financial Statements**

ALBERTA LEGISLATURE

OFFICE OF THE AUDITOR GENERAL

# Auditor's Report

To the Members of the Alberta Oil
Sands Technology and Research Authority

I have examined the balance sheet of the Alberta Oil Sands Technology and Research Authority - Oil Sands Technology and Research Fund as at March 31, 1987 and the statement of revenue, expenditure and fund balance for the year then ended. My examination was made in accordance with generally accepted auditing standards, and accordingly included such tests and other procedures as I considered necessary in the circumstances.

In my opinion, these financial statements present fairly the financial position of the Fund as at March 31, 1987 and the results of its operations for the year then ended in accordance with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

Donald D. Salmon

C.A.
Auditor General

*Edmonton, Alberta*
*June 23, 1987*

**Alberta Oil Sands Technology and Research Authority**
**Oil Sands Technology and Research Fund**

# Balance Sheet

**As At March 31, 1987**

| | 1987 | 1986 |
|---|---|---|
| ***ASSETS*** | | |
| **Current:** | | |
| Cash | $16,058,465 | $11,692,706 |
| Deposits in trust (Note 3) | — | 1,657,694 |
| Deposits on projects (Note 4) | 1,703,743 | 487,062 |
| Accounts receivable | 2,444,794 | 3,572,192 |
| Prepaid expense | 2,111 | 6,052 |
| | $20,209,113 | $17,415,706 |
| ***LIABILITIES AND FUND BALANCE*** | | |
| **Current:** | | |
| Accounts payable | $20,835,267 | $ 9,505,160 |
| Holdbacks payable | 1,100,624 | 1,772,912 |
| | 21,935,891 | 11,278,072 |
| Fund balance | (1,726,778) | 6,137,634 |
| | $20,209,113 | $17,415,706 |

The accompanying notes are part of these financial statements.

Alberta Oil Sands Technology and Research Authority
Oil Sands Technology and Research Fund

# Statement of Revenue, Expenditure and Fund Balance

For the Year Ended March 31, 1987

| | 1987 | 1986 |
|---|---|---|
| ***Revenue:*** | | |
| Contributions by the Province of Alberta | | |
| — Alberta Heritage Savings Trust Fund (Note 5) | $31,400,000 | $50,000,000 |
| — General Revenue Fund | 34,700,000 | — |
| Technology sales | 1,227,125 | 2,156,404 |
| | 67,327,125 | 52,156,404 |
| ***Expenditure:*** | | |
| In situ oil sands, net | 25,082,211 | 8,945,980 |
| Underground access | 11,248,413 | 15,691,395 |
| Institutional research | 10,486,394 | 10,289,985 |
| Bitumen upgrading | 9,911,582 | 4,651,643 |
| Heavy oil, net | 7,959,139 | 855,847 |
| Mining and extraction | 5,037,965 | 4,081,375 |
| Carbonate trend | 2,860,813 | 2,542,242 |
| Enhanced recovery | 1,306,250 | 741,141 |
| Technology handling | 559,102 | 693,749 |
| Authority costs | 448,223 | 471,612 |
| Training activities, net | 219,758 | 270,129 |
| International activities | 71,687 | 109,690 |
| | 75,191,537 | 49,344,788 |
| Excess (deficiency) of revenue over expenditure for the year | (7,864,412) | 2,811,616 |
| Fund balance at beginning of year | 6,137,634 | 3,326,018 |
| Fund balance (deficit) at end of year | $(1,726,778) | $ 6,137,634 |

# Notes to the Financial Statements

March 31, 1987

### *Note 1 Authority*

The Alberta Oil Sands Technology and Research Authority operates under the authority of the Oil Sands Technology and Research Authority Act, Chapter 0-6, Revised Statutes of Alberta 1980.

These financial statements disclose receipts of $34,700,000 as a contribution from the Province of Alberta, General Revenue Fund. There appears to be no express authority in the Oil Sands Technology and Research Authority Act which allows the Authority to accept contributions from this source.

### *Note 2 Significant Accounting Policies and Reporting Practices*

Expenditures from the Fund are not capitalized due to the intangible nature of assets that may accrue to the Authority. The Authority will be entitled to share in any assets remaining at the end of a project in proportion to its percentage of participation.

A statement of changes in financial position is not provided as disclosure in these financial statements is considered to be adequate.

### *Note 3 Deposits in Trust*

Deposits in trust consist of deposits in the General Trust Fund of the Province of Alberta

### *Note 4 Deposits on Projects*

The amount of $1,703,743 (1986 $487,062) shown on the balance sheet represents the excess of cash calls on projects over actual expenditures.

### *Note 5 Contributions by the Province of Alberta*

The Appropriation (Alberta Heritage Savings Trust Fund, Capital Projects Division) Act, 1986-87 provided for payments to the Authority to a maximum of $31,400,000 for the year ended March 31, 1987 (1986 $50,000,000).

### *Note 6 Administration Costs*

The following costs incurred in the administration of the Authority have been borne by the General Revenue Fund and are not reflected in these financial statements.

| | 1987 | 1986 |
|---|---|---|
| Salaries and wages | $2,249,489 | $2,045,637 |
| Fees and commissions | 410,978 | 442,747 |
| Rental of property and equipment | 404,603 | 305,479 |
| Employee benefits | 290,388 | 234,929 |
| Travelling and hospitality | 235,158 | 237,341 |
| Materials and supplies | 49,051 | 129,180 |
| Staff relocation costs | 29,229 | 576 |
| Telephone and telegraph | 14,805 | 14,447 |
| Freight, express and postage | 14,263 | 8,754 |
| Furniture and equipment purchases | 12,345 | 15,830 |
| Equipment maintenance | 10,624 | 11,633 |
| Advertising | 4,123 | 11,855 |
| Grants | — | 4,262 |
| | $3,725,056 | $3,462,670 |

### *Note 7 Commitments*

The Authority had outstanding commitments as at March 31, 1987 totaling $60,448,633 (1986 $72,011,025) for approved projects.

### *Note 8 Contingent Liabilities*

The Authority is involved in a number of legal proceedings. Claims against the Authority in these proceedings, which have not been reflected in the financial statements, amount to approximately $7,600,000. While the ultimate outcome of these proceedings cannot be determined at this time, it is the opinion of management that the disposition of these cases will have a minor effect on the financial position of the Authority.

### *Note 9 Recoverable Expenditures*

The following amounts represent potential future recoveries:

| | |
|---|---|
| Shell Canada Resources Limited | |
| — PRISP Project | $12,200,000 |
| — Sale of 50% interest in PRISP Project | 12,200,000 |
| Norcen International - BODO Steam Pilot Project | 6,900,000 |
| Vikor Resources - Joffre Project | 3,300,000 |
| | $34,600,000 |

Recovery of these amounts is dependent on generation of sufficient revenue by the projects. Due to the uncertainty concerning the amount of revenue which may ultimately be generated, these amounts have not been included as a receivable in these financial statements.

***Note 10 Comparative Figures***

The 1986 figures have been reclassified where necessary to conform to 1987 presentation.

***Note 11 Approval of Financial Statements***

These financial statements were approved by management.